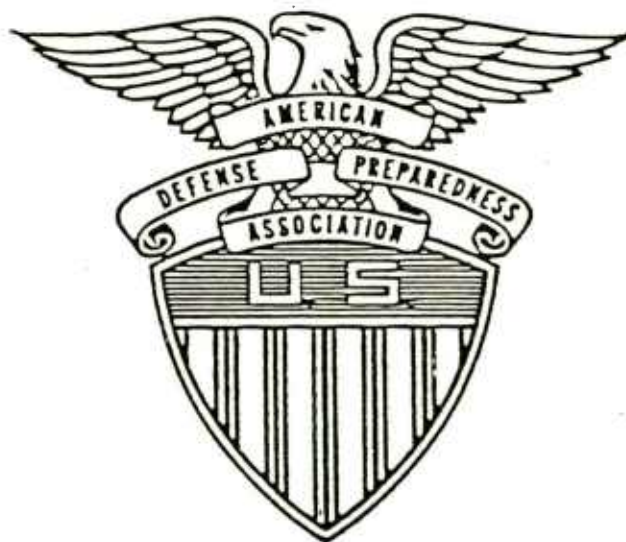


**AMERICAN DEFENSE
PREPAREDNESS ASSOCIATION**

**PROCEEDINGS
OF THE**

**ELECTRONIC TEST EQUIPMENT DIVISION'S
ANNUAL PROGRAM REVIEW
OF**

**"ELECTRONIC TEST EQUIPMENT INDUSTRY
RESPONSE TO EMERGING DEFENSE
REQUIREMENTS"**



**TECHNICAL
LIBRARY**

held at the
Hyatt Arlington Hotel
Arlington, Virginia
May 10-11, 1984

ELECTRONIC TEST EQUIPMENT
INDUSTRY RESPONSE TO EMERGING DEFENSE REQUIREMENTS

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WELCOME ADDRESS AND INTRODUCTION

FOR

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MAY 10-11, 1984

Duane Bowans
Government Marketing Manager
Tektronix, Inc.

THANK YOU FOR COMING TODAY. WE HAVE AN EXCELLENT PROGRAM PLANNED AND I GUESS YOU ALL AGREE WITH THAT OR ELSE YOU WOULDN'T BE HERE. AS I LOOK OVER THE PROGRAM AND THE LIST OF SPEAKERS, I AM REMINDED OF A STORY OF AN ANCIENT CHINESE WISEMAN. HE WAS NOTED FOR HIS WISDOM AND ABILITY TO SOLVE PROBLEMS. ONE DAY THE MINISTER OF DEFENSE CAME TO HIM WITH A PROBLEM.

"I HAVE SIX MEN AND SIX ABACUSES ON THE GUNPOWDER PROJECT, BUT MY SCHEDULE HAS SLIPPED AND I NEED ANOTHER 20 PERCENT INCREASE IN OUTPUT. COST OVERRUNS AND CONGRESSIONAL CUTBACKS PREVENT ACQUISITION OF ANOTHER MAN AND ABACUS. EVEN IF I COULD, ONE MAN WOULD NOT BE ENOUGH AND TWO MEN WOULD BE TOO MUCH."

THE WISEMAN PONDERED THE PROBLEM FOR SEVERAL DAYS AND THEN SUMMONED THE MINISTER OF DEFENSE.

"THE SOLUTION TO YOUR PROBLEM IS SIMPLE. EACH OF YOUR STAFF MUST GROW ANOTHER FINGER ON EACH HAND. THIS WILL INCREASE YOUR OUTPUT EXACTLY 20% AND WILL SOLVE YOUR PROBLEM".

THE MINISTER WAS ECSTATIC. HIS PROBLEM WAS SOLVED. HE STARTED TO LEAVE, THOUGHT A MOMENT, AND LOOKED BACK AT THE WISEMAN.

" O WISE ONE", HE SAID, "YOU HAVE TRULY GIVEN ME THE SOLUTION TO MY PROBLEM, BUT . . . HOW DO I GET MY PEOPLE TO GROW EXTRA FINGERS?"

THE WISE MAN PUFFED ON HIS PIPE.

"THAT IS A GOOD QUESTION. BUT I ONLY MAKE THE POLICY RECOMMENDATIONS. THE DETAILS OF EXECUTION ARE UP TO YOU."

THAT'S WHAT THIS GROUP IS ALL ABOUT. WORKING TOGETHER TO FIND REASONABLE WAYS TO IMPLEMENT PROGRAMS AND ACHIEVE EFFECTIVE PERFORMANCE WITHIN THE FRAMEWORK OF SOMETIMES QUESTIONABLE POLICY. FROM TIME TO TIME, IF WE ARE LUCKY, WE CAN EVEN HELP SHAPE THE THINKING OF THE WISE POLICY MAKERS, AND WHEN WE DO OUR JOB BECOMES EASIER AND THE RESULTS MORE EFFECTIVE.

THE ELECTRONICS TEST EQUIPMENT DIVISION OF THE ADPA OWES IT'S EXISTENCE TO A VERY WISE MAN INDEED. TO HIS EVERLASTING CREDIT, HE WAS ALSO A VERY PRACTICAL MAN WHO PROFERRED ADVICE AND COUNSEL FAR DIFFERENT FROM THE KIND ILLUSTRATED BY THE CHINESE WISEMAN IN THE STORY.

FOR THOSE OF YOU WHO DON'T RECOGNIZE HIM BY THE PICTURE
BEHIND ME, OUR FOUNDER WAS JOHN FLUKE SR. . . WHO DIED IN
FEBRUARY OF THIS YEAR. HIS PASSING WAS A GREAT LOSS TO THE
ENTIRE TEST EQUIPMENT COMMUNITY . . . YET HIS FORESIGHT IN
MANY AREAS HAS PERPETUATED HIS SPIRIT AND PHILOSOPHIES IN
MANY DIFFERENT WAYS AND PLACES.

THIS MEETING TODAY AND THIS ORGANIZATION IS JUST ONE EXAMPLE
OF THAT HERITAGE. I BELIEVE IT IS AN EXCELLENT EXAMPLE OF
HIS LIFE'S WORK AND IS A CREDIT TO THE MEMORY OF A VERY
MEMORABLE CITIZEN.

THE EXECUTIVE COMMITTEE OF THE GROUP ASKED ME TO EXPRESS THE
RESPECT AND CONDOLENCES OF THE DIVISION TO THE JOHN FLUKE
CORPORATION.

I'D LIKE TO READ YOU THAT LETTER EXPRESSING THOSE THOUGHTS:

TO: JOHN FLUKE, JR.

DEAR MR. FLUKE:

I WAS HONORED IN THE MID 1970'S TO SERVE ON THE DoD BLUE RIBBON ADVISORY PANEL FOR TEST EQUIPMENT CHAIRED BY JOHN FLUKE. AS YOU PROBABLY KNOW, YOUR FATHER NOT ONLY SUCCESSFULLY PRESIDED OVER THAT "AD HOC" STUDY, BUT BE BREATHED A LIFE INTO IT THAT STILL EXISTS.

THE ELECTRONICS TEST EQUIPMENT (ETE) DIVISION OF THE AMERICAN DEFENSE PREPAREDNESS ASSOCIATION (ADPA), A DIRECT DESCENDANT OF THE FLUKE COMMITTEE, IS CONTINUING THE TEST EQUIPMENT DIALOG BETWEEN INDUSTRY AND THE DoD.

THE ETE DIVISION EXECUTIVE BOARD HAS ASKED ME TO EXPRESS OUR GREAT RESPECT AND ADMIRATION FOR YOUR FATHER AND APPRECIATION FOR THE CONTRIBUTIONS HE MADE IN FOUNDING AND NOURISHING OUR ORGANIZATION, A GROUP WHICH CONTINUES TO BENEFIT ALL THOSE WHO PARTICIPATE IN IT.

THE ATTACHED BROCHURE DESCRIBING OUR ANNUAL PROGRAM REVIEW IN MAY IS INDICATIVE OF THE CONTINUED INTEREST IN THE KIND OF FORUM STARTED BY THE FLUKE COMMITTEE.

PLEASE ACCEPT FOR ALL OF YOUR FAMILY OUR CONDOLENCES ON HIS PASSING AND OUR THANKS FOR SHARING HIM WITH US DURING HIS VERY SPECIAL LIFETIME.

SINCERELY,

DUANE L. BOWANS

WE RECEIVED THIS RESPONSE FROM JOHN FLUKE JR.

THANK YOU VERY MUCH. PLEASE KEEP IN TOUCH ON THE
ETE/ADPA SUBJECT. . . . IT WAS VERY IMPORTANT TO JOHN,
SR. AND IT IS IMPORTANT TO ME.

JOHN FLUKE, JR.

NOW LET'S GET ON WITH THE WORK AT HAND. . . SIFTING OUR WAY
THROUGH THE OPPORTUNITIES AT HAND, CAPITALIZING ON THEM, AND
MAKING THE POLICY MAKERS WONDER AT OUR GREAT ABILITY TO
EXECUTE THEIR GRAND PRONOUNCEMENTS.

1984 ADPA Program Review
Electronic Test Equipment Division
10-11 May 1984
Arlington, Virginia

Trends In Defense Materiel Acquisition

By

Ms. Mary Ann Gilleece
Deputy Under Secretary of Defense
For Acquisition Management

It is gratifying to see this turnout to discuss the important issues on your agenda for this symposium. Your agenda, and the overall theme of this Annual Review, are very timely. No prior administration has ever been more keenly aware of the key role which industry plays in providing for the readiness of our Armed Forces. Of course, the Congress is equally well aware, and in their role as overseers they serve as another essential member of the team responsible for our American Defense Preparedness.

Ever since this administration came into office, with its overwhelming mandate to modernize and rebuild our Military Forces, we have been striving to accomplish that objective within reasonable budgetary constraints. But now, though Americans still want--and must have a modern and strong defense, they are calling for a more deliberate and even more cost-conscious effort.

Since we spend billions of tax dollars, the Department of Defense (DoD) receives a great deal of visibility from both the Congress and the press; and that's as it should be. We must spend our tax dollars wisely and be able to demonstrate that we are spending wisely. Otherwise, we can't expect to maintain the congressional and public support needed to carry out our rebuilding program which is so vital to achieving and maintaining an adequate defense.

In recent months there has been considerable legislative activity aimed at correcting a variety of problems involving the management and execution of the Defense Acquisition Program. Some of this activity deals with initiatives which the DoD has previously undertaken, and some of it will require that we modify existing procedures so that we can support not merely the letter of the law, but the spirit of the law as well. In doing so, however, we must avoid misapplication and the negative consequences of overzealousness. Time will not permit an exhaustive or detailed review of all these initiatives, but during the next few minutes I would like to briefly discuss a few of them which ought to be of interest to this group.

Congress is seeking to institutionalize and expand the ongoing DoD efforts to curb abuse and avoid waste. A good example of this involves the much publicized and sometimes distorted parts procurement problem. In July of last year, Secretary Weinberger sent a memo to the highest levels of management in the Services, the Office of the Secretary of Defense, and the Defense Agencies in which he outlined a program to, in his words "... ensure that we are not plagued with pricing abuses in the future...."

That program includes incentives to increase competitive bidding, reward employees who vigorously and successfully pursue cost savings, and discipline those who are found negligent in

implementing our procedures. Further, it requires that we obtain refunds where appropriate, and continue to perform audits and investigations focusing on the broad ramifications of spare parts procurement including not only the prices, but also how spares are controlled and used once they are in our inventory.

In August 1983, the Secretary issued another memo reaffirming the 10-point program which he had outlined in July, and detailing a number of specific actions to be taken. I will mention just a few of them here.

- It is now mandatory that the DoD Parts Control Program be used on all weapon system and equipment acquisitions. Most of you are familiar with the parts control program which promotes use of standard parts throughout a system acquisition cycle from engineering design through production and even into modification. This is accomplished through an engineering review of nonstandard parts and recommendation of preferred standard item replacements.

- We think that increased use of parts control will not only optimize the use of standard parts with attendant advantages in logistics support, but will also promote competition for those standard parts thereby reducing costs and minimizing sole source situations.

- Value Engineering is to be employed to investigate situations where the prices of spare parts appear to exceed their intrinsic worth. Value engineering incentive clauses are to be made mandatory for contracts over \$25,000. This replaces the old threshold of \$100,000.

- Breakout and competitive reprocurement of spare parts will be given specific consideration during source selection; and technical data is to be acquired to enable competitive reprocurement of replenishment spares.

In March 1984 Secretary Weinberger expressed his support for two new bills which were initiated in the House of Representatives, HR 4842 and HR 5064. Though some of the details in these bills may require further refinement, their thrust is to put into law the requirements and procedures which the Secretary has previously mandated by edict. Spares pricing, acquisition of technical data, resolution of data rights issues, competition advocacy, and identification of actual manufacturers and subcontractors are covered by these bills.

On the subject of technical data, I want you to know that we are not indiscriminately grabbing everything in sight. We realize that companies and individuals have legitimate rights to proprietary data, but we must acquire data unencumbered by unnecessary proprie-

tary restrictions wherever possible; and in order to do this, we must challenge proprietary data restrictions and have them deleted where appropriate. But, why acquire the data at all? Why not buy brand name "or equal"? Why not simply call out a particular manufacturer's part number? These approaches have been tried before, and they have led to the very abuses which we are seeking to correct. We must enable the DoD to buy materiel in a competitive marketplace with assurance of adequate quality, reliability and performance. Only then can we hope to achieve the materiel readiness which our Armed Forces need and deserve.

And that brings us to another issue of particular interest and concern to this Electronic Test Equipment Division. If DoD espouses the broadest possible use of commercial test equipment--and we do, how can we permit an increase in the use of Military Specifications ("Mil-Specs") for test equipment procurement? The answer is; we will use Federal or Military specifications only in the absence of suitable industry standards which can be used to ensure that the products we need are procured in a competitive environment, and that they are logistically supportable throughout their intended useful life.

As an Alternative to the use of military specifications, our Defense Materiel Specifications and Standards Office (DMSSO) has developed new procedures for use of Commercial Item Descriptions (CIDs) for use in acquisition of commercial products. Under these procedures it will be possible to encourage commercial product procurement and yet permit government-only suppliers (i.e., those without a marketed commercial product) to compete on an equal basis. Where the risk of unacceptable products is low, the CID will be a fairly simple statement of required salient characteristics. When greater detail is needed to describe a generic commercial item in order to assure the user of obtaining the type and quality product required, an expanded CID will be developed. These expanded CIDs will include salient requirements, applicable reference documents, quality assurance provisions and packaging requirements. In effect, such a CID will be tantamount to a tailored federal specification.

There are many ways to accomplish competitive procurement. Each must be measured and tailored to the task at hand, and we encourage such adaptation whenever it will serve the goal of satisfying our requirements at the least possible life cycle cost. The basic premise must be this. It is DoD policy that all goods and services shall be acquired on a competitive basis to the maximum extent practicable as a means for achieving economic, technical, schedule and supportability benefits.

We need your help in meeting the challenges of tomorrow. From my point of view, one of the greatest challenges will be to avoid unnecessary proliferation while satisfying the need for state-of-the-art technology. I sincerely hope that your working groups and committees will, in the coming year, continue to develop ideas on how to deal with this challenge. My staff will be happy to work with you, and I will be personally interested in hearing those ideas. Thank you.

LIEUTENANT GENERAL DONALD M. BABERS
DEPUTY COMMANDING GENERAL FOR MATERIEL READINESS
U.S. ARMY MATERIEL DEVELOPMENT AND READINESS COMMAND

I'M DELIGHTED TO BE HERE TO SHARE WITH YOU SOME OF THE TEST, MEASUREMENT, AND DIAGNOSTIC CHALLENGES (TMDE) THE ARMY FACES TO THE YEAR 2000 AND BEYOND. FROM MY PERSPECTIVE AS THE ARMY'S EXECUTIVE DIRECTOR FOR TMDE, I'M REASONABLY CERTAIN THAT MY COUNTERPARTS IN THE AIR FORCE AND NAVY SHARE MY VIEW THAT TMDE WILL BE A CRUCIAL CONCERN FOR THE FORESEEABLE FUTURE.

AS MOST OF YOU KNOW, DARCOM IS RESPONSIBLE FOR EXECUTING THE ARMY'S MATERIEL RESEARCH, DEVELOPMENT, ACQUISITION, AND LOGISTICS SUPPORT PROGRAMS. WE ALSO EXECUTE A VERY LARGE SECURITY ASSISTANCE PROGRAM FOR OUR FRIENDS AND ALLIES, AND WE MANUFACTURE AND SUPPLY CONVENTIONAL AMMUNITION FOR ALL SERVICES. IT'S A HUGE OPERATION AND I CAN TELL YOU THAT ITS DAY-TO-DAY DEMANDS KEEP US VERY BUSY.

AS I'M SURE YOU ALSO KNOW, THE ARMY IS IN THE MIDST OF THE MOST COMPREHENSIVE MODERNIZATION PROGRAM THAT THE ARMY HAS UNDERTAKEN SINCE WORLD WAR II. IT WILL YIELD MORE THAN 400 NEW ITEMS OF EQUIPMENT FOR OUR SOLDIERS, ALMOST ALL OF WHICH WILL REQUIRE SOME KIND OF TEST, MEASUREMENT, AND DIAGNOSTIC EQUIPMENT. THE INCREASED COMPLEXITY AND SOPHISTICATION OF MODERN WEAPONRY HAS PROMPTED THE NEED FOR TMDE APPLICATIONS THAT WERE UNHEARD OF A FEW YEARS AGO.

AMONG THE ARMY'S PRIME CHALLENGES IN FORCE MODERNIZATION ARE TO FIND SOLUTIONS TO SYSTEMS TESTABILITY, KEEP UP WITH TEST TECHNOLOGY, AND PROVIDE MODERN TMDE.

UNFORTUNATELY TODAY, SYSTEM TESTABILITY IS USUALLY CONSIDERED AFTER THE PRIMARY SYSTEM FUNCTIONS ARE DESIGNED. USUALLY THE ONLY TESTING POSSIBLE USING THIS APPROACH IS THAT WHICH SHOWS ACCEPTABLE PERFORMANCE AS THE UNITS LEAVE THE ASSEMBLY LINE. IF A FAILURE OCCURS THERE, A PRODUCER NEED ONLY REPLACE A FAILED UNIT WITH A GOOD ONE TO BRING THE WEAPON SYSTEM TO ACCEPTABLE CONDITION. HOWEVER, WHEN FAILURES OCCUR IN THE FIELD, WE FIND THAT ISOLATION TO AN INDIVIDUAL COMPONENT WITHIN THE FULL SYSTEM IS OFTEN A COMPLEX AND DIFFICULT TASK. CURRENT SYSTEM AND TEST DESIGN OFTEN RESULTS IN HIGH AMBIGUITY LEVELS FOR FAULT ISOLATION AND MANY TIMES THE ONLY PRACTICAL SOLUTION IS "SWAPPING OUT" COMPONENTS WHICH ARE USUALLY NOT READILY AVAILABLE IN THE FIELD.

MOREOVER, AFTER WE ARE ABLE TO RETURN A SYSTEM TO OPERATION, WE USUALLY HAVE A MIX OF GOOD AND BAD ITEMS LEFT OVER WHICH REQUIRE FURTHER TESTING TO MAKE SURE WE SEND ONLY FAILED ITEMS TO THE REAR ECHELONS FOR REPAIR. I'M SURE YOU CAN APPRECIATE WHAT EFFECT THIS HAS ON OUR LOGISTICS PIPELINE.

AN EXAMPLE OF THIS CONDITION BECAME EVIDENT BACK IN 1980, WHEN, TO CORRECT THE INABILITY OF THE IHAWK TO FAULT ISOLATE ACCURATELY TO THE PCB LEVEL, WE INTRODUCED THE AUTOMATIC GETS 1000 AS A SCREENER. WITHIN 2 YEARS, THE OPERATIONAL READINESS RATE FOR THE IHAWK IMPROVED BY 13 PERCENT; THE "NO EVIDENCE OF FAILURE" RETURNS TO THE DEPOT WENT FROM 41 PERCENT TO LESS THAN 10 PERCENT; AND THE COST OF PIPELINE SPARES WAS REDUCED BY \$450,000. DUE TO THIS SUCCESS, OUR PM-TMDE AT FT. MONMOUTH IS TAKING ACTION TO ACQUIRE A GENERAL PURPOSE ATE SCREENER FOR USE AT FIELD MAINTENANCE ACTIVITIES (INTERMEDIATE FORWARD AREA).

FALSE ALARM AND RETEST "OK" RATES OF UPWARDS TO 40 PERCENT OR MORE ARE ALSO NOT UNCOMMON IN MANY CURRENT SYSTEMS. FOR EXAMPLE, RECENT ANALYSIS INVOLVING OUR CH-54 HELICOPTER HAS SHOWN THAT TROUBLESHOOTING CONSUMES 50 PERCENT OR MORE OF THE TOTAL MANHOURS SPENT FOR REPAIR. THESE FIGURES SUGGEST THERE IS A LARGE POTENTIAL RETURN ON INVESTMENT (ROI) IN IMPROVED TESTABILITY AND FAULT ISOLATION PROCEDURES - - FROM A SYSTEMS APPROACH - - INVOLVING BOTH THE WEAPONS DESIGNER AND TESTABILITY ENGINEER WORKING TOGETHER FROM THE VERY BEGINNING. IN SHORT, WE ARE LOOKING FOR A DESIGN TEAM EFFORT TO COME UP WITH TOOLS TO IDENTIFY SYSTEM TESTABILITY IMPROVEMENTS, BUILT-IN-TEST/BUILT-IN-TEST EQUIPMENT (BIT/BITE) SHORTCOMINGS,

AND DEVELOP CHANGES TO REDUCE MEANTIME TO REPAIR.

ANOTHER TOPIC I'D LIKE TO DISCUSS IS THE EXTREMELY HIGH COST OF DEVELOPING A MYRIAD OF TEST PROGRAM SETS (TPS). I KNOW THAT THE ARMY SIMPLY CANNOT AFFORD THE MILLIONS OF DOLLARS IT TAKES TO DEVELOP TPS'S. WE NEED TO LOOK AT ALL POSSIBLE WAYS TO CONTROL THIS PROBLEM. I'M CURRENTLY HAVING MY PEOPLE LOOK AT THE POSSIBILITY OF REDUCING THE NUMBERS OF TPS BY ALLOWING TIME FOR THE OPERATIONAL BURN-IN OF THE SYSTEMS WE FIELD. THE CONCEPT IS SIMPLY TO PROVIDE FOR CONTRACTOR SUPPORT FOR, SAY, 2 TO 3 YEARS, AND TO ACCURATELY DETERMINE WHAT FAILS AND WHAT CAN SUCCESSFULLY BE SUPPORTED IN THE FIELD. THIS APPROACH HAS THE POTENTIAL TO ELIMINATE A LOT OF GUESSWORK OR TESTING - - MAINLY BECAUSE WE WILL KNOW HOW AND WHAT TO TEST. HOPEFULLY, UNDER THIS PROGRAM WE WILL END UP DEVELOPING ONLY THOSE TPS'S AND THE TMDE DEFINITELY NEEDED FOR FIELD READINESS OF WEAPON SYSTEMS.

ONE OTHER PROMISING AREA WE SEE THAT COULD SOLVE ARMY-WIDE PROBLEMS IN TPS GENERATION TIME AND COST IS TO WORK HAND AND GLOVE WITH COMPUTER AIDED DESIGN (CAD), COMPUTER AIDED MANUFACTURING (CAM), AND COMPUTER AIDED TEST (CAT). WE SEE AN IDEAL MARRIAGE OF DESIGN DATA BASES HERE LEADING TO THE FACTORY OF THE FUTURE AND THE ULTIMATE IN DESIGN FOR TESTABILITY.

ONE CHALLENGE I OFFER TO INDUSTRY IS TO CONTINUALLY MAKE THE SERVICES AWARE OF YOUR CAPABILITIES, ACCOMPLISHMENTS, AND IMPROVEMENTS. ONLY TO THE EXTENT THAT YOUR ADVANCES IN TECHNOLOGY ARE KNOWN TO US CAN WE KEEP OUR SYSTEMS UP TO MAXIMUM CAPABILITY.

FOR THE MOST PART, INDUSTRY CAN BE PROUD OF THE MODERN TMDE ON THE MARKET TODAY. THE GOAL NOW AND FOR THE REMAINDER OF THE 80'S IS TO BUY QUALITY TMDE AT ECONOMIC RATES AND SUCCESSFULLY DELIVER IT AND THE SUPPORT SYSTEM BEHIND IT.

FOR THE ARMY, THE CHALLENGE THAT THIS PRESENTS IS EASIER SAID THAN DONE. THE ARMY MUST MAINTAIN ITS DAY-TO-DAY READINESS -- ITS ABILITY TO WAGE WAR -- AND MODERNIZE AT THE SAME TIME. SAID ANOTHER WAY: WE MUST LEARN TO "MANAGE CHANGE" WHILE EFFECTIVELY MAINTAINING A CREDIBLE FIGHTING FORCE. ALL OF THIS, BY ECONOMIC NECESSITY, MUST BE ACCOMPLISHED ON TIME AND WITHIN COST.

THERE IS A FUNDAMENTAL FACT THAT DRIVES ALL THAT WE DO IN MODERNIZATION, AND THAT IS THE ARMY IS JUST PLAIN SHORT EQUIPMENT. BUT SINCE WE WILL PROBABLY NEVER MATCH OUR POTENTIAL ENEMY QUANTITATIVELY, IT SEEMS OBVIOUS THAT WE SHOULD RETAIN OUR QUALITATIVE EDGE.

THIS STRATEGY, HOWEVER, BRINGS WITH IT A "RIPPLE" EFFECT, BECAUSE SOME OLD EQUIPMENT WILL BE REMOVED FROM OUR INVENTORY, WHILE OTHER ITEMS WILL BE REDISTRIBUTED. AS THE ARMY'S HIGH PRIORITY UNITS (FIRST TO FIGHT) GET THEIR NEW GEAR, THE DISPLACED EQUIPMENT MUST BE REFURBISHED AND PASSED ON TO A LOWER PRIORITY UNIT.

FOR EXAMPLE, THROUGH OUR TMDE MODERNIZATION (TMOD) PROGRAM, THREE "OFF-THE-SHELF" OSCILLOSCOPES WILL DISPLACE SOME 90 MAKES AND MODELS WHICH IN TURN WILL FILL VOIDS THROUGHOUT THE ARMY, OUR RESERVES AND NATIONAL GUARD. THE LOGISTICS IMPACT IS EVIDENT - WE MUST SUPPORT ALL THE SYSTEMS CONCURRENTLY. IN EACH CASE "MODERNIZATION" IS OCCURRING AND THE MANAGEMENT CHALLENGES ARE SIMILAR.

THE PROCESS THAT I HAVE DESCRIBED IS BY NO MEANS SIMPLE. YOU NEED ONLY PAUSE FOR A MOMENT AND THINK ABOUT WHAT HAS TO HAPPEN IN THE GAINING AND RECEIVING UNITS TO APPRECIATE THE COMPLEXITY REQUIRED TO MAKE THE PROCESS FLOW SMOOTHLY. IT IS A PROCESS THAT MUST YIELD THE EQUIPMENT, THE TRAINED PEOPLE, AND THE LOGISTICS REQUIRED ON A CAREFULLY TIMED BASIS FOR BOTH THE NEW AND DISPLACED TMDE. DARCOM, THROUGH OUR PRODUCT MANAGER (PM) FOR TMDE MODERNIZATION AT FORT MONMOUTH, NJ, IS RESPONSIBLE FOR SEVERAL ELEMENTS IN THIS EQUATION AND WE KNOW HOW CRITICAL IT IS TO DELIVER WHAT IS EXPECTED OF US. ACCORDINGLY, WE

ARE MIXING PROVEN, TIME-TESTED METHODS WITH NEW APPROACHES.
WE WANT TO RETAIN THE BEST OF THE PAST AS WE SEEK
REFINEMENTS AND IMPROVEMENTS FOR THE FUTURE.

AS MUCH OF WHAT I HAVE BEEN TALKING ABOUT TODAY INVOLVES
NONDEVELOPMENT OR COMMERCIAL ITEMS WHICH WE HAVE LABELED
"NDI," I WOULD LIKE TO SHARE WITH YOU SOME OF MY THOUGHTS
ON THAT CONCEPT.

TO BEGIN WITH, WE HAVE STUDIED THIS AREA IN CONSIDERABLE DETAIL;
WE FEEL THAT THE TRADITIONAL R&D APPROACH MUST BE STREAMLINED
AND, IN SOME CASES, ELIMINATED TO ALLOW AFFORDABLE AND TIMELY
ACQUISITION AND FIELDING OF TMDE THAT SATISFIES THE USER'S
REQUIREMENTS.

FORTUNATELY FOR US, WE HAVE VIABLE ALTERNATIVES. IN MANY AREAS,
THIS COUNTRY IS BLESSED WITH AN INDUSTRIAL BASE UNPARALLELED
IN ITS DIVERSITY, INNOVATION, AND POTENTIAL. THERE'S EXCELLENT
TMDE IN THE MARKETPLACE AND WE'RE CONVINCED WE CAN USE A GREAT
DEAL OF IT AS IS OR WITH MINOR MODIFICATION, EVEN IN A COMBAT
ENVIRONMENT.

WE SEE NDI AS A MAJOR ELEMENT OF THE FUTURE FOR THE ACQUISITION
COMMUNITY. NDI DOESN'T OFFER SOLUTIONS TO ALL OUR NEEDS ...
I DON'T FORESEE THE ARMY ABANDONING THE NORMAL ACQUISITION
PROCESS FOR COMBAT MATERIEL LIKE ARTILLERY, TANKS, AND MISSILES.
YET, WE DO SEE THE NEED TO STREAMLINE THAT PROCESS TOO AND FOR

THE SAME REASONS.

IF WE CAN'T FIND WHAT WE WANT OFF-THE-SHELF, THAT DOESN'T MEAN WE HAVE TO IMMEDIATELY JUMP OFF ON AN R&D PROGRAM. WE CAN CONSIDER MODIFYING NDI, BUT WITH A GOAL OF MINIMAL CHANGE. THE FIRST STAGES OF MODIFICATIONS COULD BE MINOR AND CAN BE SUPPLIED BY THE CONTRACTOR MERELY AS PRODUCTION OPTIONS...SUCH AS "PAINT IT GREEN."

THE SECOND STAGE OF MODIFICATIONS WOULD COME UNDER THE HEADINGS OF: REINFORCE, WATERPROOF, SHOCK MOUNT, PACKAGE, OR OTHERWISE MODIFY TO ENHANCE OPERATION UNDER FIELD CONDITIONS. THE DESIGN CHANGES TO ACCOMPLISH THIS SHOULD BE STRAIGHTFORWARD, REQUIRING LITTLE R&D EFFORT AND MINIMAL TESTING.

THE NEXT STAGE COULD BE TERMED "MILITARIZATION." HERE, WE'RE GETTING INTO ACTUAL ENHANCEMENT OF CAPABILITIES WHICH MAY REQUIRE MORE SUBSTANTIAL R&D EFFORTS.

BEYOND THIS STAGE, WE ARE ESSENTIALLY TALKING ABOUT DEVELOPMENTAL PROGRAMS WITH VARYING DEGREES OF STANDARD COMPONENTS. EVEN A FULL-SCALE DEVELOPMENTAL PROGRAM USES SOME DEGREE OF STANDARD PARTS OR COMPONENTS. OUR ACQUISITION POLICY ENCOURAGES A FLEXIBLE APPROACH TO THE ACQUISITION PROCESS. ESSENTIALLY THAT MEANS, "FIND THE OPTIMUM POINT ON THE ACQUISITION SPECTRUM

THAT PROVIDES THE QUICKEST AND MOST ECONOMICAL WAY TO MEET THE REQUIREMENT."

WITH NDI, THE ARMY BECOMES AN IMPORTANT CUSTOMER IN THE COMMERCIAL TMDE MARKET, AND CAN BEGIN TO INFLUENCE THE DIRECTION AND TRENDS OF COMMERCIAL DEVELOPMENT, WHICH WILL FACILITATE FURTHER NDI ACQUISITIONS. NDI OFFERS THE OPPORTUNITY TO FIELD SOMETHING "GOOD ENOUGH" TODAY, AS OPPOSED TO A SPECIALLY DESIGNED ITEM OF TMDE WHICH COMES TOO LATE.

OF COURSE, NONDEVELOPMENT TMDE WILL HAVE TO BE SUPPORTED, AND OUR SUPPORT STRUCTURE MUST BE DESIGNED TO FIT THE SUPPORT REQUIREMENTS OF EACH ITEM AND ITS PLANNED USAGE. ITEMS TO BE USED IN A BENIGN NON-COMBAT ENVIRONMENT HAVE SUPPORT REQUIREMENTS FAR LESS CRITICAL THAN THOSE TO BE USED IN THE COMBAT ZONE.

ANOTHER CONCERN IS AVAILABILITY. WE HAVE TO SELECT NDI THAT REPRESENTS CURRENT TECHNOLOGY AND WILL BE AVAILABLE TO US, WITHOUT MODIFICATION, FOR THE INTENDED LIFE CYCLE. WE DON'T WANT TO SELECT A SPECIFIC MODEL OF EQUIPMENT ONLY TO LATER FIND THAT THE VENDOR INTENDS TO DISCONTINUE THAT ITEM. WE EITHER END UP WITH AN "ORPHAN," OR ELSE KEEP BUYING THE "NEW, IMPROVED" MODEL, RESULTING IN A PROLIFERATION OF MAKES AND MODELS IN THE INVENTORY. THE ARMY PRESENTLY HAS SOME 5000 MAKES AND MODELS OF TMDE.

MY FINAL CONCERN BRINGS ME BACK TO TESTING. ONE OF THE POTENTIAL ADVANTAGES OF NDI IS REDUCTION IN TESTING RESOURCES AND TIME. AFTER ALL, WE'RE LOOKING AT ITEMS THAT ALREADY HAVE A PROVEN TRACK RECORD. BUT IN THE CASE OF COMMERCIAL EQUIPMENT, WE CAN'T COUNT ON USING IT IN COMBAT SCENARIOS, NOTWITHSTANDING ITS COMMERCIAL ACCEPTABILITY, WITHOUT SOME REAL WORLD, USER-ORIENTED TESTS FOR COMBAT SUITABILITY. THIS WE'LL DO, WHEN NECESSARY.

THE KEY TO OUR NDI STRATEGY WILL BE THE MARKET SURVEY. A MARKET SURVEY CAN RANGE FROM A SIMPLE REVIEW OF CATALOGS ALL THE WAY TO ELABORATE SAMPLE TESTING. IN ORDER TO DO THE JOB RIGHT, WE'LL NEED INDUSTRY'S HELP. WE WILL BEGIN TO STAFF OUR REQUIREMENTS WITH INDUSTRY. THE INDUSTRY REVIEW OF OUR REQUIREMENT DOCUMENTS SHOULD HELP US SETTLE ON WHAT IS TECHNICALLY FEASIBLE AND ANSWER THE TOUGH QUESTION OF "HOW MUCH IS ENOUGH?"

UPON COMPLETION OF A THOROUGH MARKET SURVEY, WE SHOULD BE READY TO MAKE RATIONAL NDI DECISIONS. WHEN WE DECIDE TO GO THE NDI ROUTE, WE WILL CONDUCT AN IN-PROCESS REVIEW (IPR) TO APPROVE THE ACQUISITION STRATEGY. FROM THIS POINT, THERE ARE MANY OPTIONS FOR EXECUTING AN NDI ACQUISITION STRATEGY.

WE STILL HAVE A FEW SNAGS TO WORK OUT -- SUCH AS WHAT DO WE DO ABOUT THE ELIMINATION OF DOD'S ABILITY TO REQUIRE COMMERCIAL MARKET ACCEPTABILITY FROM SMALL BUSINESSES RESPONDING TO COMMERCIAL ITEM DESCRIPTIONS (CID'S) -- AND OTHER CONGRESSIONAL LEGISLATION, LIKE PUBLIC LAW 98-212, COVERING COMMERCIALITY THAT IMPACTS ON THIS CONCEPT. BUT BE ASSURED THAT FOR THE ARMY, NDI IS A PERMANENT OPTION IN OUR OVERALL ACQUISITION STRATEGY.

THESE, THEN, ARE SOME PRIME AREAS IN WHICH THE ARMY AND DARCOM ARE STRIVING TO IMPROVE THE READINESS OF MATERIEL IN THE HANDS OF OUR SOLDIERS. ONE OF THE KEYS TO READINESS IS QUALITY TMDE, WITHOUT WHICH OUR MODERN WEAPONS AND EQUIPMENT CANNOT FUNCTION -- CERTAINLY NOT ON THE BATTLEFIELD OF THE LATE 20TH CENTURY.

I KNOW THAT MANY OF THE PROBLEMS THAT THE ARMY HAS IN TMDE ARE SHARED BY OUR FRIENDS IN THE AIR FORCE AND THE NAVY. I BELIEVE THAT SOLUTIONS TO MORE THAN A FEW OF THESE PROBLEMS ARE CAPABLE OF BEING WORKED OUT DURING THIS REVIEW, BECAUSE OUR PARTNERS IN INDUSTRY CAN ALWAYS BE COUNTED ON TO DELIVER WHEN IT COMES TO QUALITY AND INNOVATION.

YOU HAVE A FORMIDABLE LINEUP OF SPEAKERS, MANAGERS, AND ADMINISTRATORS HERE, AS WELL AS A SOLID AGENDA THAT ADDRESSES THE HARD ISSUES IN TMDE. THE INFORMATION, DIALOGUE, AND RECOMMENDATIONS

THAT RESULT FROM THIS FORUM SHOULD HAVE A SIGNIFICANT
IMPACT UPON THE WAY THE DEPARTMENT OF DEFENSE (DOD) BUYS,
SUPPORTS, AND PLANS FOR TMDE--TODAY AND TOMORROW.

THE READINESS OF OUR MILITARY FORCES DEPENDS UPON SYSTEM
AVAILABILITY--WHICH IS WHAT OUR TMDE PROGRAMS ARE ALL ABOUT.
LET'S EACH OF US DO OUR PART TO ENSURE THAT OUR SOLDIERS,
SAILORS, AND AIRMEN HAVE THE TOOLS THEY NEED TO HELP KEEP
AMERICA STRONG.

THANK YOU VERY MUCH.

#

*** NOTE ***

IF THE AUDIENCE ASKS ABOUT PL 98-212 CHANGES, RECOMMEND QUESTION
BE REFERRED TO MARY ANN GILLEECE, DEPUTY UNDER SECRETARY
FOR DEFENSE FOR ACQUISITION MANAGEMENT, WHO IS ALSO A
GUEST SPEAKER.

Commo. R.O. Simon³
Deputy Commander C³I Systems & Technology Directorate
Naval Electronic Systems Command

Measurement Challenges for Emerging Technology

Good morning- its a privilege to be here this morning. Admiral Grich, Head of the Navelex Life Cycle Engineering and Platform Integration Directorate, was originally scheduled but asked me to pinch hit when he ran into a schedule conflict.

My responsibilities in Navelex are quite different from Admiral Grich's. I am responsible for the functioning of the Command, Control, Communications and Intelligence Systems and Technology Directorate. Reporting directly to me are three group leaders (two SESs and one Navy Captain with a PhD in Physics) One of my groups is charged with the systems design of new Command, Control, and Communications systems. A second group is charged with participating in fleet exercises and determining the future needs of the Battle Groups and Task Forces. My third Group(headed by a Navy Captain) is charged with maintaining a technology base from which our new system options are derived.

Therefore, as you can see, I am primarily interested in the future Navy. However, as a Naval officer with three previous commands (one ashore and two at sea), improving the workings of today's Navy is important to me.

This morning I would like to discuss the broad areas of Research and Development we at Navelex are pursuing, and also provide some specific examples of projects nearing transition to acquisition that call for new measurement challenges for these emerging Technologies. Navy systems entering the fleet, or planned for the future, represent the leading edge of technological advancement. Such areas as fiber optics, lasers, millimeter waves, and Very High Speed Integrated Circuits will be an essential part of the future Navy, and are indeed, finding their way into systems now being deployed or planned. These current and future systems present an increasing challenge to the electronic test equipment industry to provide the measurement capabilities necessary for installation, checkout, and repair. I see a strong and continuous role for the producers of commercial equipment to provide the instruments tomorrow's Navy will require. We were an early supporter of the Fluke Committee's objective of greater military utilization of commercially available equipment and continue to support this concept. 95% of the general purpose instruments that we buy are commercial off-the-shelf. The reasons are obvious: Typically we can get a better product, in less time, and at lower cost than what is generally achievable through independent development. This is possible because we share the same interests as your commercial customers in desiring rugged construction, high performance, reliable operation, at reasonable cost. The commercial market has a way of shaking these things out...

The Navy, as well as the other services, does have peculiar interests and needs and we seek to have these needs considered by the industry during the cycle of commercial development. There are many outstanding examples of where the Navy has been able to influence commercial development to our mutual benefit. Developments in oscilloscopes, electronic counters, signal generators, spectrum analyzers, and function generators are good examples. We are pleased with the trend towards rugged, field service type

construction, recessed or "clean" front panels, user friendly controls with built-in microprocessors, IEEE Bus interfacing, and extended calibration intervals. I think we expect this partnership to continue as we move into the dynamic new technologies of the 80's and 90's.

Where do I see the future Navy headed? What requirements does the future hold for electronic test equipment? The seagoing navy will have more and more complex systems aboard ships. Due to economic conditions and space limitations we cannot add additional personnel to provide support for these additional systems and functions. We can only build better hardware or improve the efficiency of our technical support. To put things in the perspective of System's design, there are various methods available to improve the reliability of the product; but no matter how much redundancy, component selection, or design debugging is used, all physical things fall under Murphy's Law and the system in time will fail. When this failure does occur, the speed of the repair will depend on the skills and experience of the technician and the capabilities of his test equipment. Although we are developing additional tools to help in doing maintenance tasks (such as improved fault isolation algorithms within the prime system) there will always be a need for both technician and test equipment. The future in the test equipment world lies in the principle that in the man/machine interface one cannot replace the other. We hope the trend is towards the machine serving man and not man serving the machine. Let's look at the youth of today who will be our next generation of technician. Machines have been a basic building block in their development; they have used them to play games, used them as learning aids in school and use them to do their homework. They have grown up with machines and in the process have become familiar and, in many ways, dependent on them. The new test instrumentation that is being developed should take advantage of this background and separate those tasks that are most suited for a machine from those that are best handled by a man.

It is safe to say our new generation of computer literate technician does not share our early fears of being replaced by a machine, instead he or she looks at them as part of the collection of tools necessary to do a job. This new perception, coupled with our goal to improve the productivity of the shipboard technician, suggests a trend towards more automation in the field environment. The IEEE interface bus, that is now common in our test equipment, is a step in that direction. Although only a hardware standard, it makes it easier to use general purpose test equipment in an automatic test mode. What we now lack and hope industry will take the lead in developing, is a software standard to compliment the existing hardware standard. This standard operating system would allow a user that does low volume testing, such as the Navy, the flexibility of configuring and reconfiguring his test system to do a particular task. We believe the first step in developing such a standard operating system is the "Reconfigurable On-Line ATE Information Distribution System" ROLAIDS for short. This approach is to build the resource description into the test instrument instead of the test program set. Each instrument has a built in standard vocabulary for communicating with different instruments on the Bus and tells the Controller what it is and what it can do. We need your help in implementing ROLAIDS or an equivalent standard software interface. The Navy buys similar instruments from many vendors. These are not necessarily Bus compatible and the technicians at sea do not have the ability or time to figure out the interface problems.

With a move towards interconnecting test equipment in a Bus architecture we must be aware of the military nuclear hardening requirements that may be imposed on our test system. As stand-alone units, the Electromagnetic Pulse (EMP) threat probably isn't that important since damage would be limited to the test devices themselves. As we move into the era of modular ATE systems where we interconnect general purpose test equipment into the prime system, commercial unhardened electronic test equipment could interfere with the operation of the prime equipment. More emphasis and priority must be given to hardening this potential weak link of the prime system chain to insure the survivability of mission essential functions.

Let us now look at some of the new hardware technologies that will be part of the Navy's future.

I earlier mentioned the impact of bus architecture in making it easier to configure special automatic test systems in the operational environment using general purpose test equipment. Bus architectures will also be important to improving prime systems.

NAVELEX is pursuing a major new effort to provide new ship construction with communication systems using the bus architecture. This is a radical departure from the past that will allow the fleet to more efficiently use its communications assets as a total system rather than a collection of stand-alone communications equipments. The system is called Integrated Communications Systems (ICS) and Shipboard Communications Network (SCAN) and was designed by exterior communications systems planners with contractor support. It is intended for installation on the new destroyer, DDG-51.

I mention this system engineered radio room because it provides new opportunities for improving the efficiency with which we can maintain and monitor such systems. The ICS will have designed in automatic monitoring using commercial products such as spectrum analyzers. Also, we are investigating techniques for doing fault isolation on the bus since we have access to the input/output ports of all the communications equipments comprising the communications system. Regarding this latter concept, there may be opportunities for new test instruments. We have not identified all fault isolating equipment yet, but commercial equipment support will be sought.

In other areas of new technology we will exploit the full frequency spectrum from 30-110 Gigahertz within the next 10 to 15 years. We now have several classified systems on board surface and subsurface platforms and within the next several years will see the introduction of the satellite communication system MILSTAR. MILSTAR will require test equipment that works above 40 Gigahertz to make the standard kinds of transmitter measurements such as power in and out, voltage, current, VSWR etc.-- equipment that will have to be operated at sea by our technicians. If all goes as planned, MILSTAR terminals will be installed by all three services, and will be used on ships, submarines, planes, and ground vehicles.

Beyond the near term plans, we are pursuing the development of broadband transmitters and receivers operating from 70-110 Gigahertz. We anticipate

testing modules that, in all likelihood, will be integrated circuits with some form of built-in digital feedback circuit in a single non-repairable package that will need to be tested as a single unit. Also, we expect to use transmitters producing hundreds of watts of cw power and likely using cryogenically cooled magnets (Gyrotron Traveling Wave Tubes).

Will the instruments be ready to help us support our new millimeter wave systems?

An even more demanding problem will be the support of electro-optic and laser systems on submarines and ships. Near term planning within the Navy anticipates the introduction of passive infra-red search and track systems within the next five years. A wide variety of systems are contemplated using fiber optics-- not only for the obvious application of data and signal bussing within the platform and system (such as the Submarine Advanced Combat System) -- but also for unique applications such as distributed underwater sensors and wideband delay lines for improved radar moving target indicators. For the long term we are very much interested in blue laser submarine communications and very low loss fiber optic cables that require new field use lasers, operating at different spectral lines.

What are some of the support problems we foresee? How can we provide a minimum number of laser testers and cover a half-dozen spectral lines from the ultra violet to the infrared? Can the maintenance be performed at the operational level by our navy technicians without undue personnel hazards (ie. eye damage)? Will we have calibration standards to provide the necessary traceability?

Another dynamic technology that is exploding is VHSIC (Very high speed Integrated Circuits). I fully expect to see some VHSIC hardware in the fleet by 1988. VHSIC enjoys high visibility in NAVELUX since several of my directorate staff comprise the Navy VHSIC manager's office. While VHSIC will offer orders of magnitude improvement in signal throughput for many types of signal processors used in Electronic Warfare, Communications, and Surveillance Systems, it could cause a maintenance nightmare for the fleet. Consider the characteristics of a Phase I VHSIC chip (1.25 micron feature sizes). The anticipated circuit clocking speed is 25 Megahertz. Each chip contains logic equivalent to 20,000 to 30,000 gates. A module will contain 6-10 VHSIC chips plus assorted "glue" chips and have input-output clocking speeds from 6-25 Megahertz. Will there be a card tester or field maintenance equipment to help our technicians? Will there be factory acceptance test equipment to help the system manufacturer? Will there be a chip tester to aid the device manufacturer?

And beyond VHSIC Phase I, we are embarking on Phase II which promises 0.5 micron feature sizes and could be introduced into the fleet in the early 1990's. Clock speeds will quadruple to 100 megahertz. Gate equivalent chip density will rise to hundreds of thousands of gates per chip, yet the module may still contain the same number of chips!

I feel that if we are to maintain VHSIC configured systems at the operational level, including fault isolation and replacement of chips on circuit boards, we will need all the skills and innovation that all of us possess. This is a most challenging task!

Within these brief remarks I have tried to provide a broad brush of where the Research and Development effort of Navelex is going and to offer some specific examples of projects now transitioning into the fleet. Hopefully this may provide your community some idea of where we need your measurement and testing support so that as a team we can move forward into the new and very challenging era of Command, Control, Communications and Intelligence requiring vastly improved data handling capabilities.

Thank you very much.

ELECTRONIC TEST EQUIPMENT INDUSTRY RESPONSE TO EMERGING DEFENSE REQUIREMENTS

THE VIEW FROM A PRIME CONTRACTOR

10 MAY 1984

GENERAL DYNAMICS

Electronics Division

P.O. Box 85310, San Diego, California 92138
619 573-7164

C.D. Nelson

Director

Product Support

GENERAL DYNAMICS

Electronics Division

PREDICT, DON'T FORECAST OVERVIEW

- THREAT
- RESPONSE
 - ANALYSIS
 - SYSTEMS
 - SUPPORT
 - MANAGEMENT
- F-16 PRODUCT IMPROVEMENT PROGRAM
- IMPLICATIONS FOR ETE INDUSTRY

THE THREAT



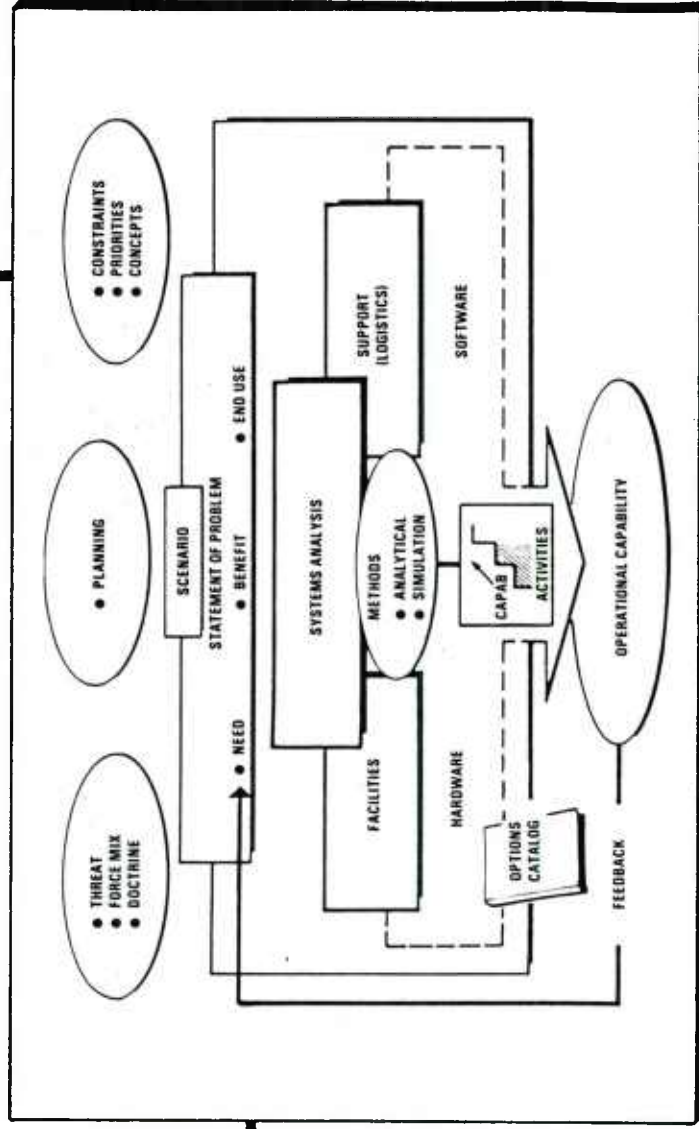
● WORLD WIDE

● TECHNOLOGICALLY DIVERSE

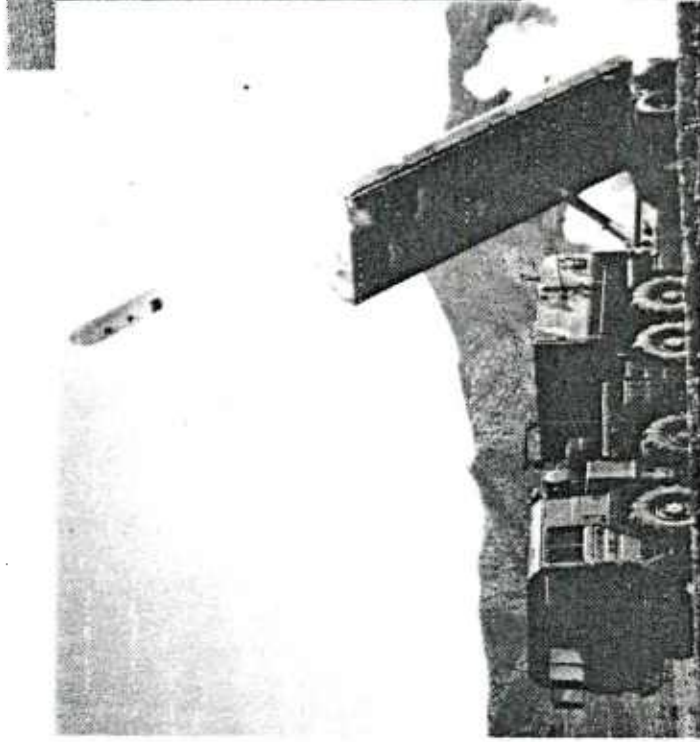
● CHANGING

THE RESPONSE ANALYSIS

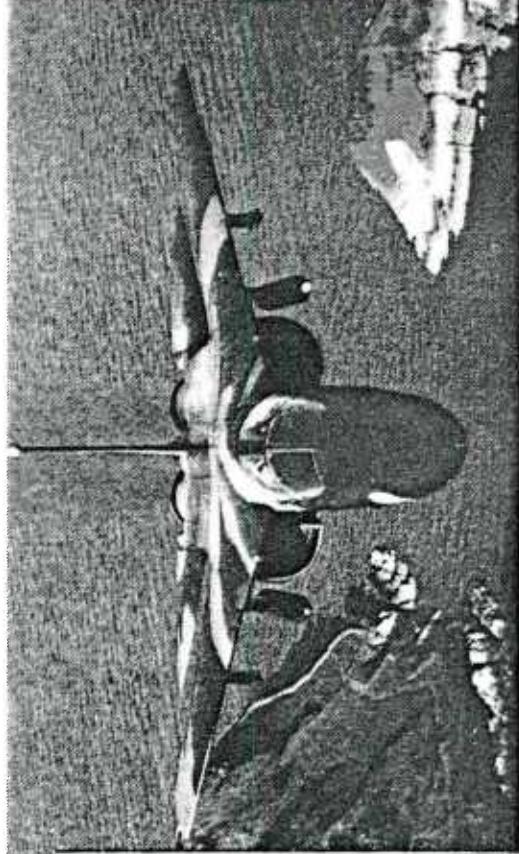
- THREAT ASSESSMENTS
 - MISSION, SYSTEMS AND OPERATIONAL ANALYSES, WAR GAMES
- IDENTIFICATION OF NEEDS
- ROLES AND MISSIONS
- SYSTEMS CONCEPTS EVALUATION LIFE CYCLE COST AND OPERATIONAL EFFECTIVENESS ANALYSES
- SYSTEM REQUIREMENTS DEFINITION
- ACQUISITION STRATEGY AND BUDGETING



WEAPONS SYSTEMS RESPONSE



GROUND-LAUNCHED
CRUISE MISSILE



FB-111A AVIONICS MODERNIZATION



M-1 ABRAMS TANK

845F-013

GENERAL DYNAMICS
Electronics Division

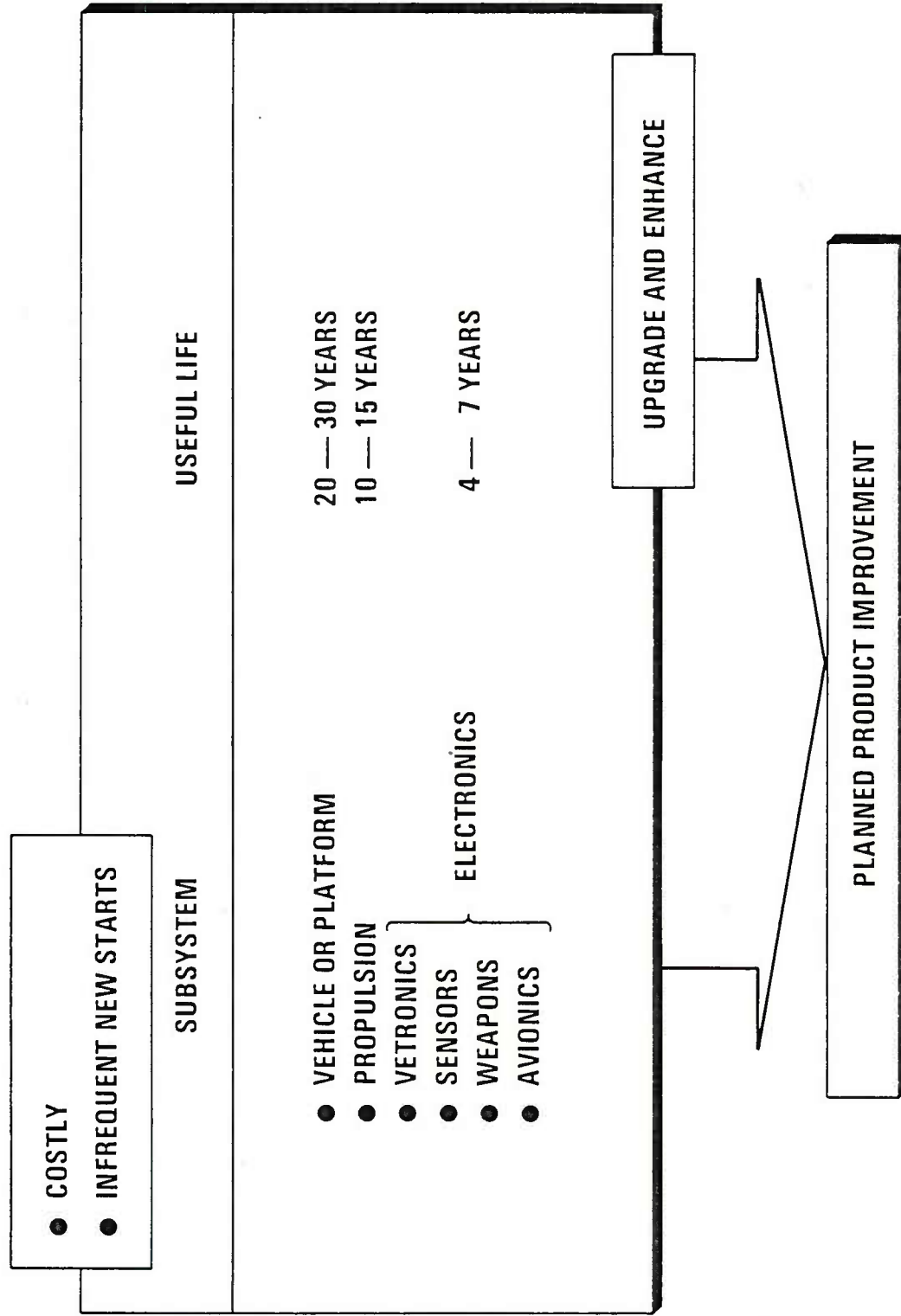
WEAPON SYSTEM SUPPORT

TACTICAL	MISSION DURATION	ELECTRONICS PACKAGING	MAINTENANCE SUPPORT	MAINTENANCE LEVELS
	DAYS TO WEEKS	VERY RUGGED, LIGHT TO HEAVY	FOLLOWS THE SYSTEM	4 → 3
SHIPS	MONTHS	RUGGED, MODERATE TO HEAVY	TAKE WITH; SOME FOLLOWS	3
AIRCRAFT	HOURS	LIGHT WEIGHT AND COMPACT	SYSTEM RETURNS	3 → 2
SPACECRAFT	YEARS	VERY LIGHT AND COMPACT	NONE TO SOME	0 → 2

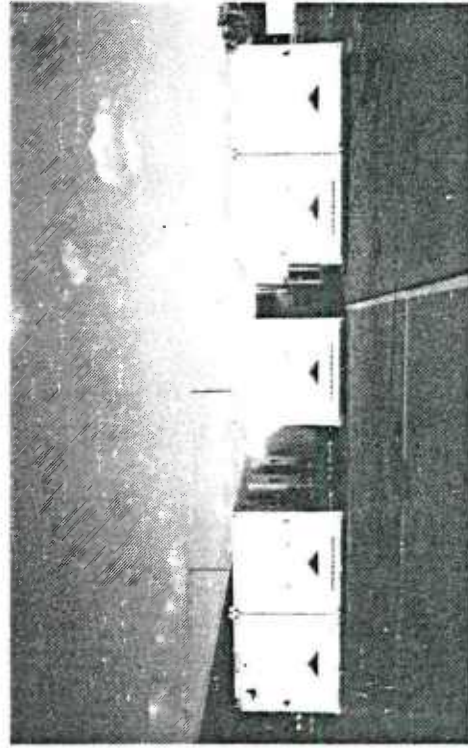
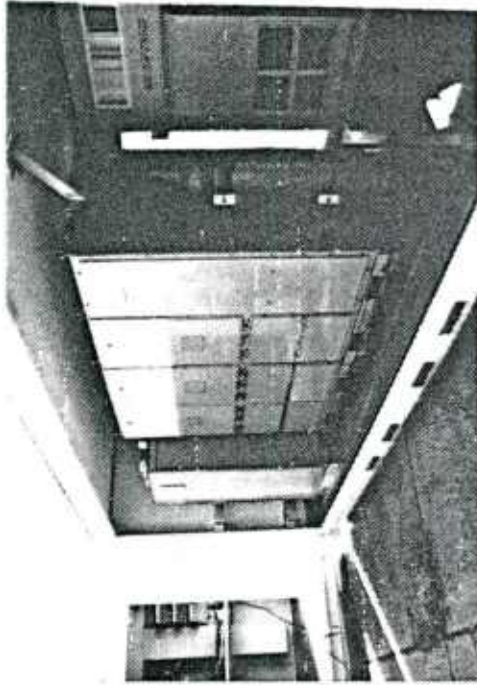
SUPPORT REQUIREMENTS

- SYSTEM DESIGN
- OPERATIONAL EMPLOYMENT
- COST EFFECTIVENESS

MAJOR WEAPON SYSTEM MANAGEMENT SUBSYSTEM LIFE CYCLES



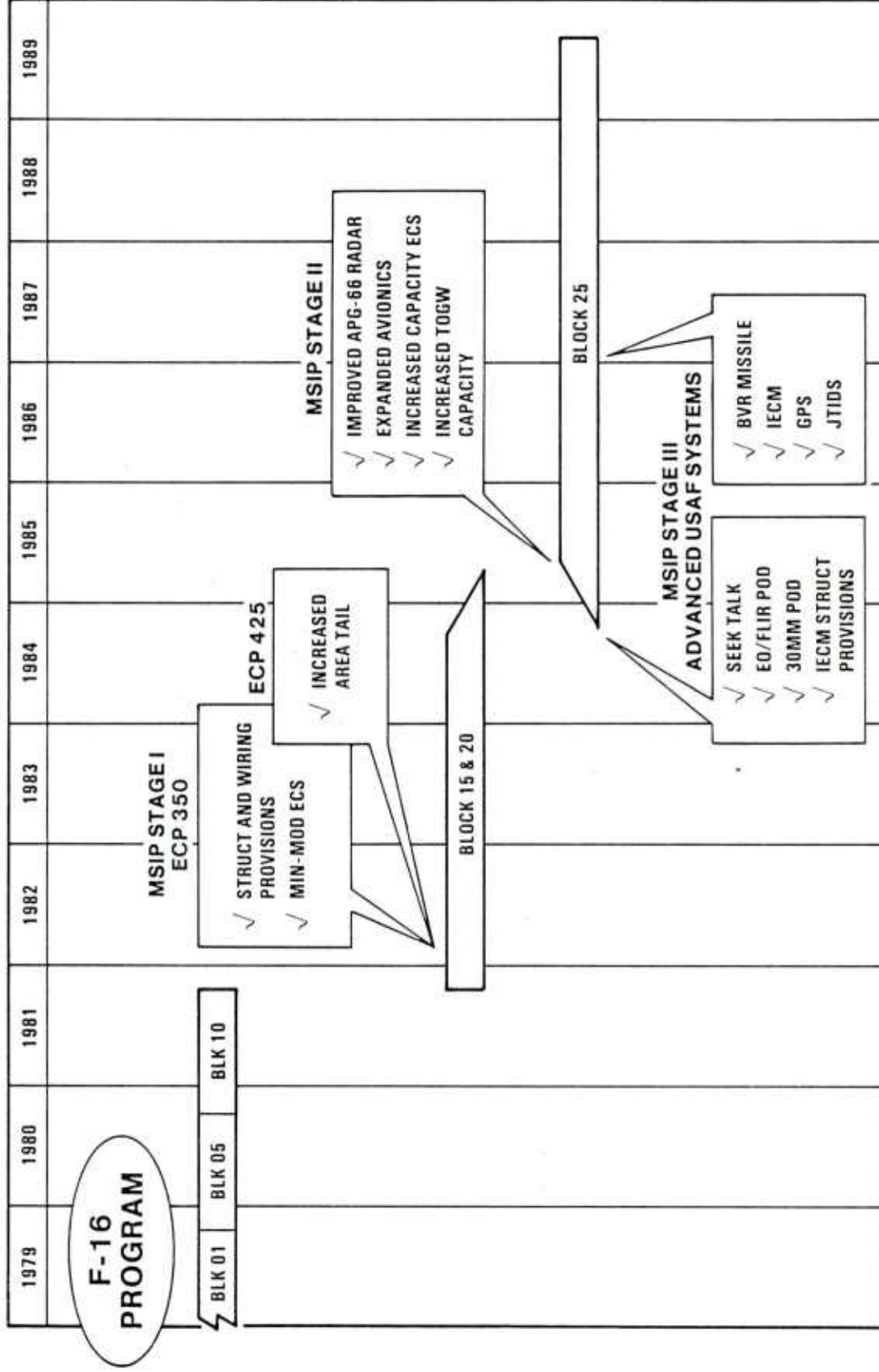
INTERMEDIATE SHOP DEPLOYABLE IN TACTICAL SHELTERS



845F-014

GENERAL DYNAMICS
Electronics Division

F-16 IMPROVEMENT PLAN



MSIP II LRU SUPPORT COMPARISON

TEST STATION	QUANTITY OF LRUs		QUANTITY OF ITAs	
	F-16 A/B	MSIP II	F-16 A/B	MSIP II
COMPUTER INERTIAL	15	4 NEW + 1 MOD	9	3 NEW + 1 MOD
DISPLAYS INDICATORS	11	4 NEW + 0 MOD	9	4 NEW + 0 MOD
PROCESSORS PNEUMATIC	13	2 NEW + 1 MOD	10	2 NEW + 1 MOD
RADIO FREQUENCY	11	2 NEW + 1 MOD	9	2 NEW + 1 MOD
TOTALS	50	12 NEW + 3 MOD	37	11 NEW + 3 MOD
MSIP II AIS CAPABILITY	65 LRUs (30% INCREASE)		51 ITAs (38% INCREASE)	

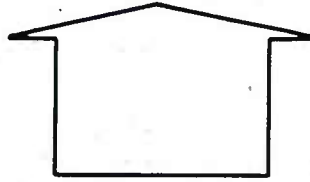
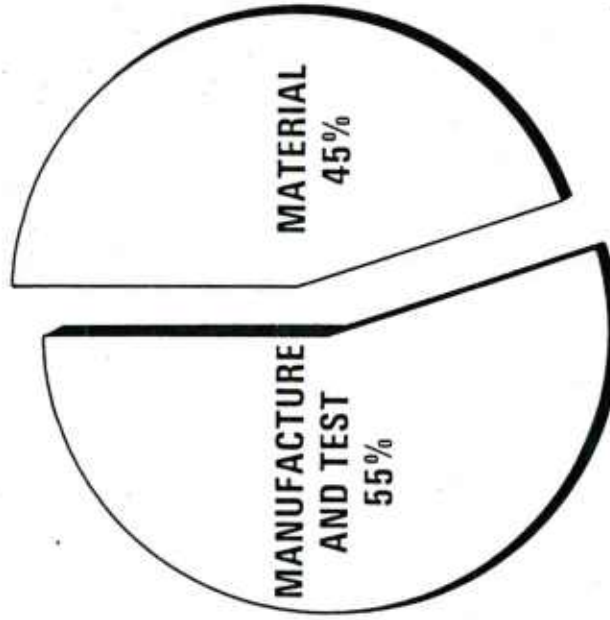
MSIP AUTOMATIC TEST EQUIPMENT PRODUCT IMPROVEMENT

- NO CHANGE TO
EXISTING TPSS
FOR A/B
AIRCRAFT
- EXPANDED
INTERFACE
- ADDED TEST
CAPABILITY
 - HARDWARE
 - SOFTWARE



INTERMEDIATE AUTOMATIC TEST EQUIPMENT

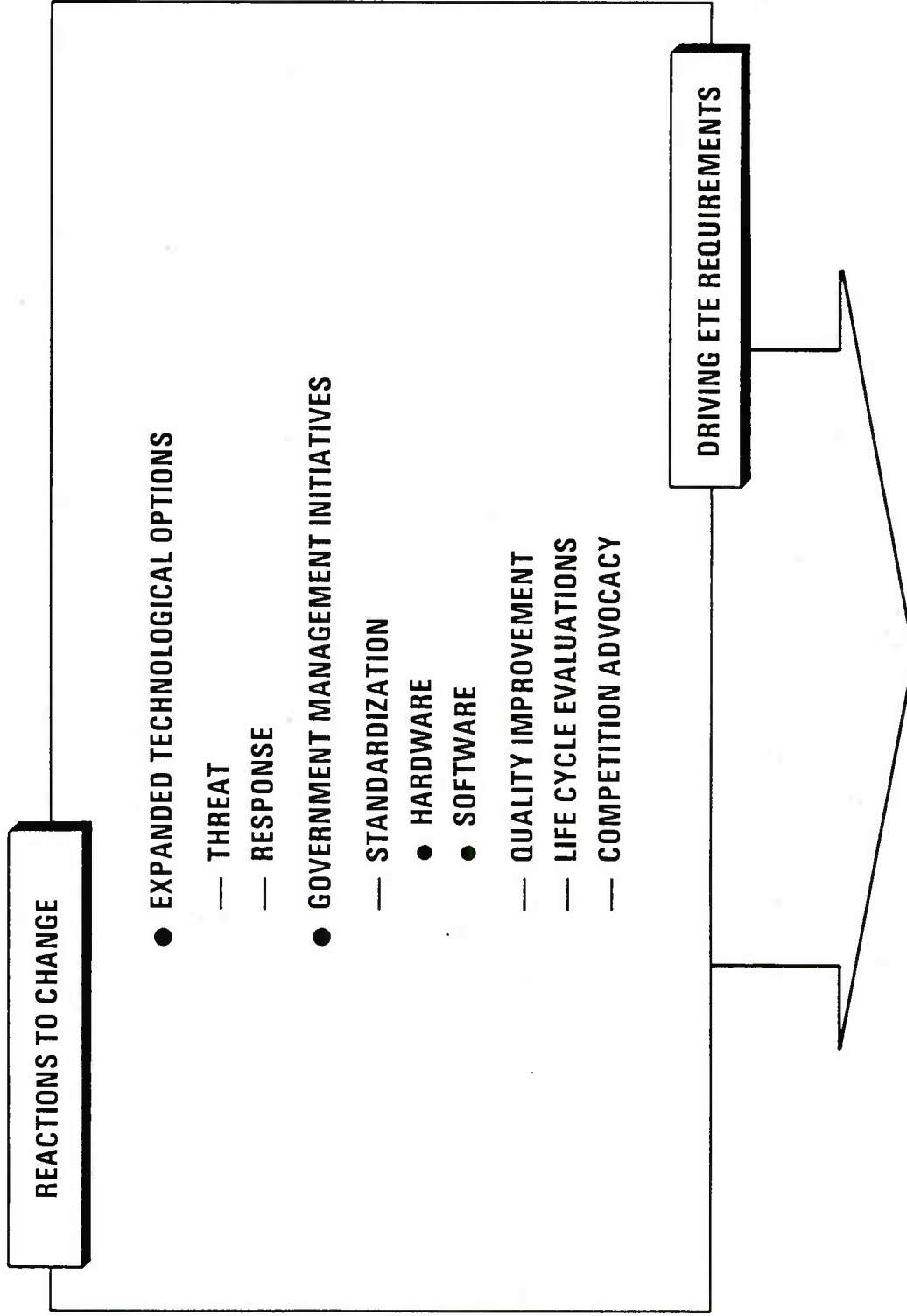
TYPICAL RECURRING COSTS



	PERCENT
— COMPUTERS	8
— RF INSTRUMENTS	19
— POWER SUPPLIES	16
— COMPONENTS AND PIECE PARTS	57

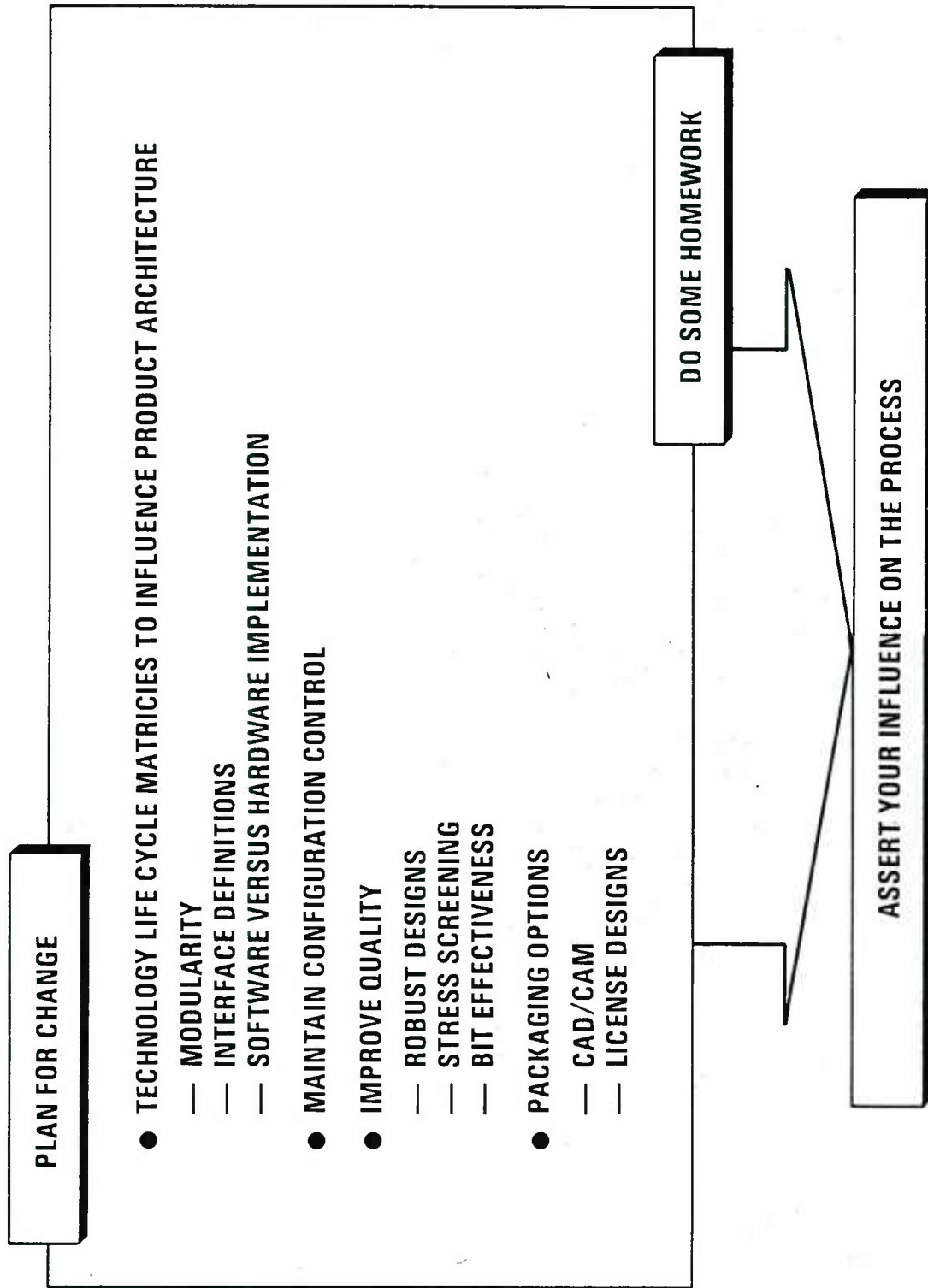
IMPLICATIONS FOR ETE INDUSTRY

PREDICT, DON'T FORECAST



IMPLICATIONS FOR ETE INDUSTRY

PREDICT, DON'T FORECAST



Eugene F. Fallon, Manager Government Affairs
GenRad, Inc.

Welcome to the Acquisition Section's portion of this year's Program Review.

Those of you who attended last year's session will recall that one of our speakers, Walter White of Fort Monmouth, spoke on "Simplified Acquisition Techniques". Walter speculated on ways to reduce time and paperwork in the procurement process by making use of the on-line computer resources of both the procurement agency and the suppliers.

I am pleased to inform you that the proposal has now moved forward, and that the General Services Administration together with several suppliers are actively testing a program of automated procurement. Our first speaker will describe the program and tell us of the results of this test.

Our speaker was also with us last year. As Special Assistant to the Administrator of GSA he described Multiple Award Schedule changes. Today, as Acting Assistant Administrator for Federal Supply Service, he is in a position to implement significant changes in the procurement process.

Ladies and Gentlemen, our first speaker, Mr. Donald C.J. Gray.

AUTOMATED PROCUREMENT SYSTEM

Donald C.J. Gray, Acting Assistant
Administrative Federal Supply & Service
General Services Administration

Chairman's Summary:

Mr. Gray began his remarks by reviewing current changes at the General Services Administration designed to achieve a world class reputation. The Federal Supply & Service Section is now being operated as a profit making corporation with marketing personnel handling customer affairs and controllers handling financial matters.

The FSS currently has eight supply facilities and 52 self-service stores handling over a billion dollars in sales yearly. Growth is predicted at 20% per year over the next three years. There are currently 6,000 Multiple Award Contracts resulting in anticipated sales of \$2.3 billion 1984.

Starting in October 1983 the GSA began to design an automated procurement system. The system was recently tested through the cooperation of several suppliers including Hewlett-Packard, IBM and Ballantine Laboratories, as well as procurement agencies at Ft. Monmouth and NAVELEX. Essentially, all communications of the automated procurement system are handled by electronic mail, thus saving time and money. In one experiment a complete procurement from solicitation to issuance of a contract was handled in just 18 minutes.

Mr. Katzman of Ballantine Laboratories, commented that the equipment required to participate in the automated procurement system costs less than \$2,000 including software, and that no special skills were required on the part of the participants.

The following is a summary of the current and proposed automated procurement system:

CURRENT

GSA mails to Commerce Business Daily the Synopsis Notice of Intent to Solicit

GSA mails Solicitation to interest vendors

Vendors return offer, filling in data where required

Negotiate for best terms and conditions

GSA makes Award and mails contract

GSA publishes and distributes Schedules of accepted contracts to Agencies

Agencies select item and order direct from vendor

Vendors ship merchandise and mail invoices to Agencies

Vendors report dollar value ordered by generic item only: no model number, quantity or Agency data

PROPOSED

GSA transmits to Commerce Business Daily the Synopsis Notice of Intent to Solicit

GSA transmits Notice of Solicitation availability so interest vendors can access it electronically

Vendors respond electronically to "Fill-in" prompts.

Negotiate for best terms and conditions

GSA makes Award and notifies vendor electronically

GSA loads accepted contracts to file with matrix of characteristics and prices for each model

Agencies select item and transmit a standard purchase order electronically

Vendors ship merchandise and electronically transmit invoices, using a standardized format

GSA electronically receives copies of orders into a marketing file

Eugene F. Fallon,
GenRad, Inc.

Another topic discussed at last year's Program Review was "Life Cycle Costing". This subject, which is an attempt to determine True Cost of Ownership versus Initial Procurement Price, has been a topic of interest for several years. Its implementation has been delayed due to the difficulty in fairly determining and weighing the parameters to be used in this procurement technique.

Again, since our last Program Review, much progress has been made on the subject. Two services are now implementing this technique.

Here to give us an overview of this subject and to introduce our subsequent speakers is Mr. Tony Ramsden of Marconi Instruments.

LIFE CYCLE COSTING

Mr. Tony Ramsden,
Marconi Instruments

Chairman's Summary:

Mr. Ramsden reviewed the progress made in Life Cycle Costing since his talk to ADPA in 1983. He then introduced the first speaker, Mr. Richard Maryanski, Chief, MOD Management Division, Test Equipment Modernization, U.S.Army.

USE OF LIFE CYCLE COSTING IN TMDE
MODERNIZATION PROCUREMENTS

Mr. Richard Maryanski, U.S.Army

A. Current Acquisition Approach - 2 Step Invitation for Bid (IFB)

1. Step 1 - Letter Request for Bid Samples

- (a) Performance Testing
- (b) Facility of Use Evaluation

2. Step 2 - Invitation For Bid

- (a) Current Cost Elements - Hardware, Documentation, Initial Training

B. Potential Life Cycle Cost Elements

- 1. Investment Cost Elements
- 2. Operation and Support Cost Elements
- 3. Criteria for selection

- (a) Significant contribution to total cost
- (b) Provides differentiation between bidders
- (c) Verifiable

C. Percent Contribution of Cost Elements to Life Cycle Cost

1. Hardware Cost (57 - 69%)

- (a) Significantly contributes to total cost
- (b) Included (priced) in Step 2 bids

2. Engineering Cost (2%)

- (a) Government in-house cost
- (b) Does not vary by bidder

3. Initial Training (1%)

- (a) Does not contribute significantly to total cost
- (b) If required, included (priced) in Step 2 bids

4. Transportation (0.5 - 4%)

- (a) Does not contribute significantly to total cost
- (b) Does not provide differentiation between bidders

5. Documentation (2%)

- (a) Does not contribute significantly to total cost
- (b) Required - currently included (priced) in Step 2 bids

6. Inventory Management (1 - 16.5%)

- (a) Cost to enter and maintain an item and its' repair parts in the inventory
- (b) Significantly contributes to total cost
- (c) Difficult to implement - would require submission of provisioning data by each bidder and screening by Government
- (d) May not provide differentiation between bidders
- (e) Penalizes state-of-the-art design

7. Replacement Training (1.5%)

- (a) Does not contribute significantly to total cost
- (b) Use of cost estimating techniques to determine which would not provide a differentiation between bidders

8. Consumables (7.7 - 11%)

- (a) Cost of repair parts for maintenance
- (b) Use of cost estimating techniques

9. Holding (1.3%)

- (a) Not expected to differ between bidders

10. Maintenance/Calibration Fixture & Accessories

- (a) Cost of extender boards, breakout cables, etc.
- (b) While cost not expected to be significant, must be built/procured early to support initial fielding
- (c) One set of fixtures/accessories to be submitted by each bidder in Step 1
- (d) Evaluated during Facility of Use evaluation
- (e) List included in Step 2 IFB as priced option

11. Initial Provisioning (4.5 - 6.5%)

- (a) While not significantly contributing to total cost, it will be included to take advantage of the Step 2 competition
- (b) Recommended list provided by each bidder in Step 1
- (c) Evaluated during Facility of Use evaluation
- (d) List provided in Step 2 IFB as priced option

12. Maintenance/Calibration Labor

- (a) Significantly contributes to total cost
- (b) Input data required for calculations
 - 1. Government Input
 - 2. Inputs required from bidders
- (c) Minimum acceptable MTBF and maximum acceptable MTTR in Government specifications
- (d) Each bidder bids MTBF and MTTR
- (e) Verification of bid values

13. Summary of Life Cycle Cost Elements to be Utilized

14. Test Case of Life Cycle Costing Technique

- (a) Distortion Analyzer TS-4084/G - part of FY85 Test Equipment
- (b) Step 1 Letter Request for Bid Sample to be released week of 14 May 84

USE OF LIFE CYCLE COSTING IN TMDE MODERNIZATION PROCUREMENTS

CURRENT ACQUISITION APPROACH

2 STEP IFB

COST ELEMENTS

Hardware
Documentation
Initial Training

CRITERIA FOR SELECTING LIFE CYCLE COST ELEMENTS

SIGNIFICANTLY CONTRIBUTES TO TOTAL LIFE CYCLE COST
PROVIDES DIFFERENTIATION BETWEEN BIDDERS
MUST BE VERIFIABLE

POTENTIAL LIFE CYCLE COST ELEMENTS

INVESTMENT: Hardware
Engineering
Initial Training
Transportation
Documentation
Initial Provisioning
Maintenance/Calibration Equipment

OPERATION/
SUPPORT: Inventory Management
Replacement Training
Maintenance Labor
Calibration Labor
Consumables
Holding

PERCENT CONTRIBUTION OF COST ELEMENTS TO LIFE CYCLE COST (based on Economic Analysis of AN/PSM-45, AN/USM-488, AN/USM-489, AN/USM-490)

<u>ELEMENT</u>	<u>PERCENT</u>
Hardware	57-69
Engineering	2
Initial Training	1
Transportation	0.5-4
Documentation	2
Inventory Management	1-16.5
Replacement Training	1.5
Consumables	7.7-11
Holding	1.3
Maintenance/Calibration Fixtures & Accessories	--
Maintenance/Calibration Labor	3.8-16.9

INPUTS FOR MAINTENANCE AND CALIBRATION LABOR COST

Number of years of operation
Number of Equipments
Number of Hours of Operation/Year
Hourly Wage
Mean Time between Calibration (MTBC)
Mean Time between Failure (MTBF)
Mean Time to Repair (MTTR)
Mean Time to Calibrate(MTTC)

MAINTENANCE AND CALIBRATION LABOR COST

MTBF: Minimum Acceptable MTBF in Government Specification
Each Bidder Bids an MTBF
Value no lower than specification value
Wimring bidder must meet value bid
MTBF Verified in Group D Reliability Test (MIL-STD-781C)

MTTR: Same Technique as for MTBF
MTTR Verified in Group E Maintainability Demonstration (MIL-STD-471A)
Determined by Government during Bid Sample Testing

SUMMARY OF LIFE CYCLE COST ELEMENTS TO BE UTILIZED

Hardware
Initial Training
Documentation
Initial Provisioning
Maintenance Labor
Calibration Labor
Maintenance/Calibration Fixtures and Accessories

Mr. Ramsden next introduced Mr. Malven E. Schneider, Programming Manager
Dialectic Corp. His topic was "Possible Use of Life Cycle Costing in TMDE
Modernization Procurement".

PROCUREMENT UTILIZING LIFE CYCLE COSTING CRITERIA
MALVEN E. SCHNEIDER
APPLIED TECHNOLOGY ASSOCIATES, INC.

Mr. Maryanski has described the Army approach to using Life Cycle Costing in their modernization program. I would like to discuss an approach being used by the Navy, and to offer some remarks comparing the two approaches.

Both efforts are directed toward providing means for considering supportability and cost of ownership of commercial test equipment. Both use basic life cycle costing techniques in a 2 step acquisition approach. The differences in technique are primarily a function of equipment usage and inventory size.

The Army program applies LCC to the selection and high-volume procurement of commercial test equipment, both off-the-shelf and modified, for use in a stand-alone mode with total organic logistic support.

The Navy program applies LCC to the selection and small quantity procurement of unmodified off-the-shelf commercial test equipment for use as fully integrated subsystems of larger manual and automatic test systems, with reliance on manufacturer capabilities for depot-level logistic support.

Background

About two years ago NAVAIR tasked ATA to assess the use of Commercial Test Equipment (CTE) in Automatic Test Equipment. Should it be used? Under what conditions or constraints? How should it be acquired and managed?

We concluded that, given improved selection, acquisition and management processes, CTE offered NAVAIR some significant advantages. We provided a conceptual description of these processes -- the keystone of which was long-term supportability assessment through life cycle costing.

We looked at the LCC elements, reviewed a number of LCC models, and developed a simplified LCC methodology. We then developed a suggested contract Statement of Work which incorporated both the data requirements and the necessary assurances with which to estimate and control life cycle costs. The Statement of Work and a detailed product support questionnaire were distributed to representative CTE manufacturers for comments and suggestions. Responses to this survey were used to modify the Statement of Work and methodology to accommodate the level of information and assurance which the survey indicated could be obtained from manufacturers.

While the major focus of our efforts had been on new ATE system development, an application opportunity presented itself in the form of an update to an existing system. It is that trial application which I will describe today.

Commercial Test Equipment Replacement Program

The AN/AWM-23 Weapon Control System Test Set, deployed in the early 70's includes within its five test stations a wide range of commercial instruments. Since these instruments have become increasingly obsolete, NAVAIR has initiated a series of change proposals to authorize their replacement. These changes are directed toward retrofit of the benches with minimal design impact and:

- o Selection of replacement items by joint NAVAIR/Prime efforts;
- o Station interface development by the Prime;
- o Acquisition of instruments by the Navy; and
- o Delivery of instruments as Government Furnished Equipment.

The replacement program is being implemented through a series of change proposals. The proposal covering two of the five stations, Low Frequency Test and Computer Test has been approved and is in process. Proposals for the RF Test and the Controls/Displays, Doppler Filter Test have been submitted for approval. This sequence permits evaluation and selection of instruments capable of use in all five, thus minimizing the proliferation problem.

Equipment Requirements

The current efforts for the LFTS and CTS change are focused on the following replacement requirements:

<u>Type</u>	<u>Stations Affected</u>
Digital Multimeter	5
Counter/Timer	5
Oscilloscope	5
Spectrum Analyzer	1
Frequency Response Analyzer	2
Magnetic Tape Reader	1

Notice that the equipment complement of these two stations includes instruments used on the remaining stations.

Equipment Evaluation Process

Identification of candidate replacements was accomplished through the joint efforts of the Prime Contractor and NAVAIR activities. The initial criteria included basic performance requirements, expected availability, and commonality with other NAVAIR applications. This preliminary screening provided a set of equipment candidates which were then subjected to a thorough evaluation.

<u>Type</u>	<u>Candidates</u>
Digital Multimeter	6
Counter/Timer	2
Oscilloscope	2
Spectrum Analyzer	3
Frequency Response Analyzer	2
Magnetic Tape Reader	4

The equipment evaluation process includes three major areas of concern; technical, supportability, and life cycle cost.

Technical considerations include detailed performance specifications, form/fit/function compatibility with existing station design, availability off-the-shelf with no "Special" modifications or alterations, and the accessibility and maintainability of the equipment design and construction. These evaluations are conducted through documentation review, discussions with and visits to manufacturers, and "hands-on" examination and use of equipment furnished by the manufacturers.

Supportability Considerations include such factors as the production life of the item, the manufacturers capability and procedures for supply and repair services, Navy experience with like items and manufacturer service capabilities, and the product support commitments provided by the manufacturer. These evaluations are conducted through dialogue and correspondence between the NAVAIR activities, the manufacturers, and ATA.

Life Cycle Cost considerations include initial acquisition and operation and support costs for the equipment across all AWM-23 stations. A subset of the LCC provides budgetary estimates for the specific change proposal being processed. The evaluations were conducted through research of technical manuals and detailed data inquiries to manufacturers.

Life Cycle Cost Concept

o Consider Equipment-Driver Costs

The LCC objective during selection and acquisition is to distinguish between the several candidates. The model is structured to meet this objective by considering equipment-driven rather than government-controlled costs. The manufacturer is provided with: quantity of instruments to be installed and to be placed on site as spares; the number and qualifications of personnel to be trained; the quantity of technical manuals and other data to be delivered, and; the nature of product and data change notification required. The manufacturer identifies the possible and recommended support alternatives; the costs for manufacturer support within the recommended alternative; the costs associated with other deliverables; and written assurance with respect to production and support plans. By this means, all government-incurred costs are known and baselined across all candidates.

o Tailor to Available Data

Classic LCC models and analyses encompass all costs involved in development, production, use and disposal of an item or system. They are generally expressed in the functions and semantics of the MIL-SPEC environment. In the CTE environment many of those functions are inseparable from the unit cost and the semantics are frequently foreign to the business language of the manufacturer. The methodology accepts the data available from the manufacturer and includes techniques for using these data to develop such factors as Mean Time Between Failure of modules and parts.

o Provide Feedback to Manufacturer

Results of each LCC evaluation are provided to the manufacturer for review and comment. Changes to original input are accepted where they are factually supportable.

o Provide Individual and Comparative Data to NAVAIR

Results of the LCC evaluations are provided to all participants in the selection process. The LCC data is supplemented by any significant facts such as accessibility, weight, or other attributes of a candidate which should be considered in the selection process.

LCC Element

The LCC evaluation addresses the following cost elements:

- Initial Acquisition
- Spares/Repair Parts
- Navy Maintenance
- Factory Repair
- Support Equipment
- Technical Data
- Packaging
- Transportation
- Training
- Inventory Management

These elements differ from those considered in the Army approach.
Why?

- To provide an evaluation of the consequences of the latitude permitted in satisfying minimal baseline requirements imposed by the Government.
- To force decision makers to consider all facets of their decision and avoid surprises.
- To satisfy the LCC "purist" without major estimating effort.

Let me highlight some specific element considerations which differ from the norm.

Spares/Repair Parts costs are based on unit cost data provided by the manufacturer which are then applied to Navy-developed quantities to be provisioned.

Factory Repair costs are separately identified since manufacturer repair of modules was advocated as the norm rather than the exception.

Technical Data costs include initial delivery of data as well as subscription costs for all product bulletins, change notices, and other materials which describe configuration changes made or planned by the manufacturer.

Training costs are based on manufacturer responses to a baseline training requirement which defines numbers and qualifications of students, course locations and course schedules.

Current Status

The candidate evaluation processes for the LFTS and CTS were completed on 31 January. A complement of instruments was selected, with LCC a major contributor to selection. The evaluation and feedback process has generated increased LCC awareness and interest on the part of the manufacturer's involved.

The original plans, to use the candidate selection process results as justification for sole-source procurement, have been altered. The process is now being treated as an informal step 1 in the 2 step process. The results of the evaluations provide the baseline requirements for soliciting and evaluating competitive bids. Bids will be subjected to technical, supportability and LCC evaluations with the results compared, where possible, with earlier evaluation baseline data.

Summary

- o LCC is an essential consideration in the selection and acquisition of CTE.
- o LCC can be effectively employed without severe impact on either the Navy or industry.
- o The AWM-23 CTE replacement program will provide a continuing opportunity to demonstrate and refine the use of LCC in the CTE selection and acquisition process.

COMMERCIAL TEST EQUIPMENT PROCUREMENT UTILIZING LIFE CYCLE COST CRITERIA

LCC CONTRIBUTORS (2) AWM-23 REPLACEMENT

<u>ELEMENT</u>	<u>DMM(5)</u>	<u>C/T(2)</u>	<u>SCOPE(2)</u>	<u>SA(3)</u>	<u>FRA(2)</u>	<u>MAG. TAPE READER</u>
HARDWARE*	45-52	48-55	42-45	38-46	29-40	19-36
INIT. TRAIN.*	1-8	0-6	3-8	0-3	3	3-6
TRANSPORT.	1	1	.1	0-37	.01-0.8	0.1-26
DATA*	.3	.4	.2	.5	0.8-1.5	0.5-1.4
INIT. PROV.*	23-31	27-28	24-26	19-36	41-49	15-38
INV. MGT.	4.8-16.7	6-20.6	8-12	0-4.6	2-9	3-21
MAINT. LABOR*	7.5-20.5	2-14.5	11.5-17.9	0-12	2-10	1.4-28
CONSUMPTION	.1	0	0	.1	0-3	0.6-5.8
SUPPORT EQUIP.*	1	1	2	0-6	.01-8	1.1

NAVY BID SAMPLE EVALUATION

As a long time commuter in Washington D.C. Area, I was going to speak on our local highway system, but Col Holt said it must be related to test equipment. Then I selected "The Technical Use of Implied vs Stated Contract Warranties ", but Mr. Katzman, very diplomatically, suggested this topic," Navy Bid Sample Evaluation."

Navy bid sample evaluation is unlike the olympics: It is a continuing, on-going event; we have no order of finishers (all items either pass or fail); we have no gala ceremonies or symbols (like the olympic torch); we are very straight forward and we're not subjected to political pressures; and we're not a large, expensive budget item (like construction of new arenas).

As a baseline, let me define 4 terms:

GPETE - General Purpose Electronic Test Equipment (85-90% of Navy's current Test Equipment)

C B S - Competitive Bid Sample (before contract, often referred to as "Fly before Buy")

FAT - First Article Test(s) (after contract award; this is not what I advocate!)

BNOE -Brand Name or Equal (The Navy's primary means of competitive procurements

I'll talk about:

- . General procedures regarding Navy test equipment,
- . Specific Navy competitive bid sample test procedures, and
- . Current procurement considerations for Navy test equipment.

First, Let me relay a real life, horror story related to testing, or lack thereof. In mid 1970's we started getting reports that a new oscilloscope we procured was no good, or in Navy terms "N.F.G." Investigations quickly disclosed that it was the probes, not the scopes, which were the problem. All probes are considered consummable in the Navy supply system (like light bulbs or toilet paper), and a sailor should use whatever is in the supply system. We discovered probes were purchased in lots of 10,000 or more, to no meaningful purchase spec and with no testing. The low bidder (generally a "bicycle shop") then distributed his product to all the Navy Supply Centers and the operating forces were supposed to use that probe. The only way a sailor could get another probe was to either get his boss' boss' boss' permission to spend their own money for their own probes, or throw the junk probes overboard and "draw down" the supply system in hope that the system will eventually respond.

In 1977 we implemented a CBS Program for the Navy; we wrote a realistic purchase spec (we discussed attenuation, frequency response, workmanship, etc.) Then we tested Bid Samples, before we purchased, to make sure they performed. Today the Navy is delivering good solid performing probes procured on CBS Basis. All DOD, thru Defense Electronic Systems Center, Dayton, Ohio is occasionally following suit.

General Navy Procedures Regarding Test Equipment

Following are Basic Navy Principals :

- (1) My command, NAVELEX-NAVAL ELECTRONIC SYSTEMS COMMAND-Washington D.C. (actually located in Crystal City, Va), is the overall technical authority and manager;

- (2) SPCC-Navy Ships Parts Control Center-in Mechanicsburg, PA is the Navy's purchasing agent for both new requirements and replacement requirements;
- (3) In all cases, we use MIL-T-28800, the general specification for all test equipment which is a joint service and industry coordinated document;
- (4) We typically procure commercial off the shelf GPETE; and
- (5) We have no R&D funds or a test equipment development program.

Navy Competitive Bid Sample Test Procedures

Step-by-step of Navy's procedures include the following:

- . First, we prepare a tailored purchase description using MIL-T-28800, the measurement requirement, and our engineering judgement. This is generally a B.N.O.E. salient characteristics specification.
- . Second, all competitive procurements (70-80% of our total funds) are two step procurements; the first step is for technical evaluation, the second step is for price evaluation.
- . Third, we usually request two samples per item bid for testing in step I of the procurement. The only exception may be the brand name's equipment.
- . Next, the Bid Sample are tested and evaluated at one of two Navy laboratories (we do all of our testing in-house). All testing is done in accordance with the detailed purchase description or salient characteristics (which always reference MIL-T-28800).

. Lastly, we at NAVELEX make the final decision on the evaluation;
in other words, the labs make recommendations to us and we advise SPCC what is acceptable (for step II of the procurement).

Current Navy Procurement Considerations

We are considering some sort of life Cycle Support cost to expand our successful bid sample test program, to encompass more than the instant procurement costs. Not only initial procurement costs, we're thinking Total Life Cycle Cost, including:

- . Cost to re-calibrate
- . Cost to Repair
- . ILS costs
- . Initial spares or interim repair parts
- . Actual field or fleet tests
- . Increased reliability tests
- . and other meaningful pre-award testing.

Ralph O. Compton

ELEX 8151

GPETE ENGINEERING AND

PROCUREMENT BRANCH HEAD

1982
NATIONAL MEASUREMENT REQUIREMENTS
SURVEY

MAY 1983

NATIONAL CONFERENCE OF STANDARDS LABORATORIES
NATIONAL MEASUREMENT REQUIREMENTS COMMITTEE

NOTE

THIS PAPER PROVIDES THE SUMMARY OF THE 1982 NATIONAL MEASUREMENT REQUIREMENTS SURVEY REPORT, NMRC 83-01. COPIES OF THE COMPLETE REPORT MAY BE OBTAINED FROM NCSL SECRETARIAT KEN ARMSTRONG, (303) 497-3787.

Delbert H. Caldwell
Naval Metrology Engineering
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1982

NATIONAL MEASUREMENT REQUIREMENTS SURVEY

Prepared by

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NMRC Survey Questionnaire	

*Not Included, see Note on first page.

INTRODUCTION

During 1982, a survey of over 1400 United States companies, government organizations, and universities was conducted to assess our overall National measurement requirements. The broad objectives of this survey were to:

- o Identify requirements for new or improved calibration services from the National Bureau of Standards (NBS) that are necessary for National interests including commerce, international competitiveness and defense preparedness.
- o Identify new measurement requirements to establish or improve technical, quality and productivity aspects of individual organizations.

The survey was conducted in two parts. Part I was used to assess the scope of the National measurement requirements and identify organizations with specific needs for further study. Part II of the survey was forwarded only to those organizations which had indicated a need for: (1) a new or improved NBS calibration service; or (2) a new or improved local measurement capability beyond what could be obtained commercially.

The responses to the survey have been reviewed in depth by NMRC technical subcommittees comprised of industry and government metrology experts, and discussed in detail in subcommittee meetings and workshops. The results of the subcommittee reviews are presented in this report for use by industry, the National Bureau of Standards, and other government organizations, and universities to aid in guiding efforts necessary to maintain this Nation's leadership in the world.

D. H. Caldwell

Chairman, National Measurement

Requirements Committee

SECTION 1

ASSESSMENT OF THE 1982 NMRC SURVEY

RESULTS - PART I

During 1982, a questionnaire was distributed to 1,464 organizations within the United States to assess the overall degree of satisfaction with the current state of metrology and to highlight needs for new or improved capabilities. The specific areas targeted for study were:

- o Needs for new or improved calibration services from the National Bureau of Standards that are necessary for National Interests;
- o Needs for new or improved measurement capabilities within organizations that are necessary to establish or improve technical, quality or productivity aspects of the individual organizations product or service.

Organizations indicating a need in either of these two areas were contacted during the Part II of the survey.

The 1,464 organizations receiving the Part I questionnaire included commercial and aerospace companies, government activities and laboratories and selected universities. The distribution for the questionnaire was derived from the NCSL membership list representing 487 organizations and the mailing list for NBS Special Publication 250, Calibration and Related Measurement Services of the National Bureau of Standards, representing 977 additional organizations.

The total responses received was 411 or 28% of those surveyed. The distribution of these responses by source is indicated in Table 1.

TABLE 1
SURVEY RESPONSE DISTRIBUTION

	<u>SURVEY QUANTITY</u>	<u>RESPONSES PERCENT</u>
INDUSTRY	346	84%
GOVERNMENT	61	15%
UNIVERSITIES	4	1%
	<hr/>	<hr/>
TOTAL	411	100%

The details of the 411 responses are indicated in Table 2.

TABLE 2
PART I - 1982 NATIONAL MEASUREMENT REQUIREMENTS SURVEY

Section A: NBS Calibration Service Requirements

1. Are NBS services directly required by your organization?

YES: 300 (74%) NO: 105 (25%) TOTAL: 405

2. Do NBS services meet your current or foreseen requirements?

YES: 188 (60%) NO: 124 (39%) TOTAL: 312

TABLE 2 - CONTINUED

PART I - 1982 NATIONAL MEASUREMENT REQUIREMENTS SURVEY

3. Your needs are for:

a. A new service:	29 (20%)
b. An improved service:	46 (32%)
c. Both a new and improved service:	65 (46%)

TOTAL: 140

4. New or Improved Service Required:

a. Reference or transfer standard calibration:	88 (34%)
b. Product or component testing:	15 (5%)
c. Reference material or data:	33 (12%)
d. Measurement Assurance Program (MAP):	49 (19%)
e. Measurement seminars:	39 (15%)
f. Other:	30 (11%)

TOTAL: 254

5. New or Improved Service Need:

a. Immediate	88 (52%)
b. Near term (1-3 years)	66 (39%)
c. Intermediate term (3-5 years)	10 (5%)
d. Far term (5-10 years)	4 (2%)

TOTAL: 168Section B: Measurement Requirements

1. Do existing/foreseen calibration or measurement requirements exceed your present capabilities?

YES: 194 (49%) NO: 201 (50%) TOTAL: 395

TABLE 2 - CONTINUED

PART 1 - 1982 NATIONAL MEASUREMENT REQUIREMENTS SURVEY

2. Your need is for:

a. A new calibration capability:	71 (25%)
b. An improved calibration capability:	118 (41%)
c. A new test or measurement capability:	37 (13%)
d. An improved test or measurement capability:	57 (20%)
TOTAL:	<u>283</u>

3. New or improved calibration or measurement capability desired:

a. Calibration of reference or transfer standards:	138 (41%)
b. Calibration of portable test equipment:	64 (19%)
c. Calibration of automated test equipment:	61 (18%)
d. System/product testing:	25 (7%)
e. Subassembly/component testing:	6 (1%)
f. Material/Process testing:	11 (3%)
g. Troubleshooting/fault diagnosis:	27 (8%)
TOTAL:	<u>332</u>

4. Calibration or measurement capability need:

a. Immediate:	94 (40%)
b. Near term (1-3 years):	117 (49%)
c. Intermediate term (3-5 years)	16 (6%)
d. Far term (5-10 years):	8 (3%)
TOTAL:	<u>235</u>

In conclusion, while some interesting detailed relationships and inferences can be drawn from the Part I survey data, the evidence clearly points out the following:

NBS Calibration Services

- o 40% of the reporting NBS calibration service users indicate a need for a new or improved service.
- o 91% of the reported new or improved service requirements are needed now - 3 years.

Organization Measurement Capability

- o 49% of the responses indicate a need for a new or improved calibration, test or measurement capability within the company or organization.
- o 90% of the reported new or improved measurement capability requirements are needed now - 3 years.

SECTION 2

ASSESSMENT OF THE 1982 NMRC SURVEY

RESULTS - PART II

SECTION 2A - OVERVIEW

During 1982, a questionnaire was distributed to 193 organizations that had responded to Part I of the NMRC survey and indicated that needs existed for new or improved metrology services and capabilities. The purpose of this follow-up questionnaire was to obtain technical details on:

- o The reported needs for a new or improved NBS calibration service;
- o The reported needs for new or improved local measurement capabilities.

The total responses received initially from this Part II questionnaire was 49 or 25% of those surveyed. The responses were predominately from industry and represented a reasonable cross-section of organizations conducting measurements or calibrations as part of their operations.

Overall, the 49 responding organizations indicated 259 requirements for new or improved measurement services/capabilities. The distribution of these 259 requirements is shown in Table 3.

TABLE 3
REPORTED CALIBRATION/TEST REQUIREMENTS

1. NBS Transfer Standard Calibration Service:	84	(32%)
2. NBS Product/Component Test Service:	30	(12%)
3. NBS Measurement Assurance Program (MAP):	46	(18%)
4. NBS Miscellaneous Services:	49	(19%)
5. Organization Local Calibration or Test Capability:	50	(19%)
TOTAL:	<u>259</u>	

The NBS transfer standard calibration service requirements shown in Table 3 are further broken down by broad measurement technology areas as shown in Table 4.

TABLE 4

NBS TRANSFER STANDARD CALIBRATION
SERVICE REQUIREMENTS

1. DC-LF Metrology:	20 (24%)
2. RF-Microwave Metrology:	24 (29%)
3. Electro-Optical Metrology:	10 (12%)
4. Temperature Metrology:	7 (8%)
5. Physical Metrology:	14 (17%)
6. Chemical Metrology:	2 (2%)
7. Miscellaneous:	7 (8%)
TOTAL:	<hr/> 84

The responses to Part II of the survey have been reviewed in depth by five NMRC subcommittees comprised of over 40 industry and government metrology experts and discussed in detail in subcommittee meetings and workshops with other government and industry metrologists. The findings were supplemented and reinforced by follow-up discussions with survey respondents and other technical experts in the field.

In summary, the responses indicate critical needs for NBS Calibration services in over 20 measurement areas. The impact of not having the NBS calibration service now or in the very near future is reported as significantly affecting the following:

- o Quality of goods and services
- o Readiness of National defense capabilities
- o Costs to develop and maintain independent capabilities
- o Unverifiable product performance
- o Test/Measurement disputes
- o Consumer prices
- o High technology product development and international commerce.

Details of the findings of the NMRC subcommittees are provided in the following sections.

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F-111 Automatic Test Equipment Replacement Program
Lt Col Thomas J. Mackey, USAF Program Manager F-111
Avionics Intermediate Shop (AIS) Replacement Program
SA-ALC Kelly AFB Texas

Supportability is a key word in the United States Air Force today. It was a key element in the past, but new technology especially in the electronics area has and is continuing to allow the Air Force to do more in the supportability area than previously imaginable. New avionics being developed or recently fielded not only has greater capabilities and accuracies, but also improved reliability. The mean-time-between-failure (MTBF) rate of many of the Air Force's new avionics systems are much higher than those experienced in the past. Along with improvements in MTBF reliability, the Air Force has continually stressed the necessity for improvements in repairability and mean-time-to-repair (MTTR). Progress has been made in this area through careful consideration of testability during the design cycle of new systems. While systems are in design, testability features can be introduced into the new equipment such that fault detection and isolation can, in many cases, be accomplished by the equipment itself. This fault detection and isolation capability normally referred to as BIT (built-in-test), has become one of the many standard requirements on new Air Force contracts. The F-111 Automatic Test Equipment Replacement Program is one of those new programs in which BIT and supportability are key and paramount considerations. The remainder of this paper will address the F-111 Avionics Intermediate Shop (AIS) Test Station Replacement Program.

The F-111 aircraft fulfills a unique role in the defense of this country and our NATO allies. It is the United States' only all-weather, day/night, high and low level fighter/bomber. It is one of the most, complex aircraft in the Air Force inventory. This complexity provides it with capabilities that far exceed most of the aircraft in our inventory. This same complexity that provides the unique capabilities also provides some unique and challenging maintenance problems. To insure adequate supportability for the aircraft, the Air Force, during the design phase for the F-111 not only specified the degree of built-in-test (BIT) for the avionics, it also embarked on a new philosophy of intermediate maintenance which has been dubbed with an appropriate name--the Avionics Intermediate Shop or AIS. The F-111 was the first Air Force aircraft to employ the AIS test station concept. This concept proved its value and is also used in the F-15 and F-16 as well. The B-1 will also use a similar maintenance concept.

The heart of the F-111 AIS is the test stations upon which all avionics maintenance fault detection and isolation is performed. These test stations like the avionics that they support are subject to age, wear, deterioration and obsolescence. Such is the case for the F-111 AIS. Developed in the early 1960's with the technology of that era, the F-111 AIS test equipment has far exceeded its life expectancy. These test stations were designed for a life expectancy of 10,000 hours, but now many of them have amassed two and three times that number of hours. This age coupled with ever increasing occurrences of parts obsolescence (no replacement or substitute) drove the Air Force to consider either a drastic modernization of the old test stations or total replacement. Considering all factors and the very real probability that the F-111 will be in the active inventory for at least another twenty-five years,

the Air Force elected to pursue the course of total test station replacement, because it provided the most capability for the least total life cycle cost.

The Air Force embarked on a major acquisition effort aimed at replacing the present F-111 AIS as quickly as practical, but at the same time developing replacement equipment that contained state-of-the-art technology that would provide the best supportability. Supportability for not only maintenance of the F-111 avionics, but also maximum supportability for the new test stations themselves. To attain this, the Air Force very carefully and purposefully put together a contract specification package that, if fulfilled by the successful offeror, would result in the fielding of a highly supportable AIS system. The contract requirements specifications were developed with the full understanding and appreciation for maintenance and supportability problems of not only the original F-111 AIS, but also other AIS systems fielded since the F-111.

The F-111 AIS contract specification package focused particular attention to not only reliability, but maintainability, supportability and adaptability as well. For reliability, an MTBF of 175 hours per test station was specified as a realistic and attainable requirement. This number is only attainable, however, if the contractor chooses the test station elements carefully so that no individual or accumulation of components jeopardizes the requirement. Also, a critical factor is an inherent test station design requirement for sufficient cooling. Inadequate cooling has been a silent killer for many other similar programs. Maintainability requirements were not only stated in terms of mean-time-to-repair (two hours), but also in the maintenance philosophy and associated requirements such as: software, fault detection and isolation, technical data, computer aided manual troubleshooting, automatic built-in-test and the physical configuration of the test stations and accessory items. Supportability was specified at a fifteen years minimum, but in addition, station configuration was to be modular, to make maximum use of a common core (like instruments from station to station), maximum use of off-the-shelf commercial instruments and software, and a maximum use of the MATE (Modular Automatic Test Equipment) philosophy for both hardware and software. Adaptability is also a key element which is necessary to insure that the first or second aircraft avionics modification does not cause premature obsolescence or major redesign of the new test equipment. The contract requirements for adaptability were covered through the requirement for a 30 per cent growth capability in both the new hardware and software. In addition, all known future modifications to the F-111 fleet through the next several years were identified. Through careful design and selection of test station elements, this requirement should also be fulfilled.

All requirements of the F-111 AIS replacement program are attainable and once achieved they will provide one of the best AIS systems available. The task, however, is not an easy one. Putting the contractual words and requirements outlined in the previous paragraphs into an efficiently and effectively designed AIS system is a tremendous task. It will take a team effort of not only contractors, but Air Force/Contractor team work as well. We are and will continue to nurture that team work and team spirit in order to develop the support and supportability required to keep the F-111, the most unique of Air Force aircraft adequately supported and mission ready. That support will be provided through the new AIS and thus allow the F-111 fleet to continue to fulfill its key and critical role in our national defense.

F-111 AVIONICS INTERMEDIATE SHOP (AIS) REPLACEMENT

- F-111 UNIQUE IN DEEP STRIKE, NIGHT, ALL WEATHER CAPABILITY
- SCHEDULED FOR SERVICE PAST 2010
- KEY ELEMENT IN NATIONAL DEFENSE - - 17% OF BOMBER FORCE, 10% OF
FIGHTER FORCE
- THREE LEVEL MAINTENANCE CONCEPT - ORGANIZATIONAL, INTERMEDIATE & DEPOT
- INTERMEDIATE MAINTENANCE ACCOMPLISHED ON TEST STATIONS IN AVIONICS
INTERMEDIATE SHOP (AIS)

F-111 AIS REPLACEMENT (BACKGROUND)

- AIS IS KEY ELEMENT IN MISSION READINESS - - IF NOT OPERATIONAL, AIRPLANES CAN'T LAUNCH
- OLD AIS TESTERS ARE ON EDGE OF NON-RELIABILITY AND OBSOLESCENCE
- REPLACEMENT DETERMINED TO BE MOST COST EFFECTIVE APPROACH TO PROVIDE ESSENTIAL CAPABILITY
- LESSONS LEARNED ON OTHER AIS DEVELOPMENTS TO FORM BASIS FOR MANY NEW REQUIREMENTS
- PRACTICAL COMMON SENSE APPROACH USING NEW STATE-OF-THE-ART TECHNOLOGY

F-111 AVIONICS INTERMEDIATE (REQUIREMENTS)

- TEST STATION FAULT DETECTION - - 100 PER CENT
- CONFIDENCE TESTING - - OPERATIONAL ASSURANCE/FAULT ISOLATION
- FAULT ISOLATION, 95 PER CENT TO 2 SRU'S - 90 PER CENT TO 1 SRU
- COMPUTER AIDED MANUAL TROUBLESHOOTING
- AVIONICS LRU FAULT DETECTION/FAULT ISOLATION - - 95% TO 2 SRU'S
- 90 PERCENT TO 1 SRU EXCEPT WHERE PROHIBITED BY LRU DESIGN

F-111 AIS REPLACEMENT (REQUIREMENTS)

- RELIABILITY 175 HRS
- MAINTAINABILITY 2 HRS
- AVAILABILITY .85
- SUPPORTABILITY 15 YEARS
- MODULAR AUTOMATIC TEST EQUIPMENT (MATE) DESIGN PHILOSOPHY
- MAXIMUM USE OF COMMERCIAL OFF-THE-SHELF HARDWARE AND SOFTWARE
- 1985 AVIONICS BASELINE WITH 30 PER CENT BUILT IN GROWTH CAPABILITY

F-111 AVIONICS REPLACEMENT

- PROGRAM REQUIREMENTS/REALISTIC AND ATTAINABLE
- AIR FORCE/CONTRACTOR EFFORT
- OPERATIONAL SUPPORT SYSTEM A MUST FOR FULLY MISSION CAPABLE
FLEET

AIR FORCE BID SAMPLE TESTING

by

Lt Scott W. Halwes

INTRODUCTION

This briefing outlines the SA-AIC Kelly AFB Bid Sample program, and discusses the policies, channels, and testing associated with it.

POLICIES

It is the policy of the DoD as well as the Air Force to procure electronic test equipment when it will meet AF requirements. This eliminates problems which stem from procuring custom made equipment.

Pursuant to the DAR 202.4(b), the equipment offered must be suitable from the standpoint of "facility of use." Accordingly, bid samples are subjected to tests specified by the government in conjunction with the following general "facility of use" test categories to verify minimum government requirements (these requirements are also known as salient characteristics).

- Operational peculiarities, such as the IEEE 488 GPIB talker/listener for ATE capabilities
- Workmanship.
- Component quality and arrangement.
- Application compatibility.

CHANNELS

Step 1

When the project engineer realizes (a.) a recurring need for a certain piece of electronic test equipment in the field or (b.) a vital need to upgrade/update ATE in the field, he writes a Purchase Description (PD) which is the specification that the commercial electronic test equipment must meet in order to fulfill the Air Force's minimum performance requirements.

When funds are available, the item managers write a Purchase Request (PR) which then sets aside funds for the resultant contract.

At this time, the contracting officer solicits industry for bid samples. The contractor normally has forty-five (45) calendar days from the issue of the solicitation to submit a bid sample package. This bid sample package consists of two (2) instruments with the manufacturer's Operation and Maintenance Manual and acceptance test procedures applicable to the item offered. Also, an additional copy of the O and M Manual is sent to the project engineer via the contracting officer. The project engineer reviews the Manual and may disqualify the item due to a nonconformity to the PD.

The bid sample lab receives the bid sample, tests it, and writes the report for the project engineer.

The project engineer evaluates the bid sample lab's report and officially approves/disapproves the instrument. The government is given sixty (60) days from receipt of the package to evaluate the package.

When the contracting officer receives written word of a package passing/failing, he then notifies the vendor of his package's status. Notice that at no time does the contractor hear of his bid sample's status through the project engineer or the lab technicians. All correspondence of this nature is done through the contracting officer.

CHANNELS

Step 2

The contracting officer asks for prices from the vendors whose bid samples passed testing. The approval of a bid sample does not constitute a waiver for any of the requirements of a PD which applies to any contract resulting from Step 2.

The contract is awarded to the lowest bidder.

TESTING

The following MIL-T-28800 bid sample inspections are performed in accordance with the MIL-T-28800 examination and test methods.

- Preoperational inspection
- Operating temperature
- Humidity
- High/Low temperature
- Vibration
- Shock pulse
- Bench handling
- Input power consumption
- Voltage and frequency variation
- Dimensions
- Weight
- Mechanical stability
- Front panel markings
- Performance tests (Group A and B)
- EMI rationale

Vendors are not allowed in the Bid Sample lab at any time. This provides the needed confidentiality for each bid sample package.

Each bid sample package is allowed two (2) failures. A failure is defined as a nonconformance to the salient characteristics (section 3 requirements) of the PD.

After the first failure of an instrument, the tests which were assigned to that instrument are reassigned to the other instrument. Failure examination or failure repair by the vendor will not be permitted at this time.

After the second failure, testing on both instruments will stop. The vendor will be allowed to examine both instruments but repair only one. Testing will then resume on the instrument which the vendor chooses to repair. Except where technically non-feasible, all repairs will be to the lowest discrete component level.

After the third failure, testing on that instrument will stop and the bid sample package will be declared unacceptable.

BID SAMPLE PROGRAM ADVANTAGES

The Bid Sample program does achieve DoD policy by procuring commercial electronic test equipment.

The Bid Sample program saves both the Air Force and industry R and D funds by buying commercial, readily-available electronic test equipment.

The Bid Sample program gives the Air Force a feel for the equipment before we procure it.

The Bid Sample program allows for a much quicker procurement than with First Article testing. In many cases, it takes half the time to deliver an item to the field with a Bid Sample contract than with a First Article contract.

The vendor can respond much quicker to a Bid Sample solicitation than would be possible if the vendor needed to "tool up" to manufacture the item. The Bid Sample method does not infringe on any proprietary data since commercial equipment is involved.

BID SAMPLE PROGRAM PLANS

SA-AIC is making plans to expand our EMI capability by incorporating an EMI laboratory into the proposed MATE Qualification Center.

KELLY AFB

BID SAMPLE PROGRAM

DOD POLICY

- IAW DOD MANUAL 4120.3-M

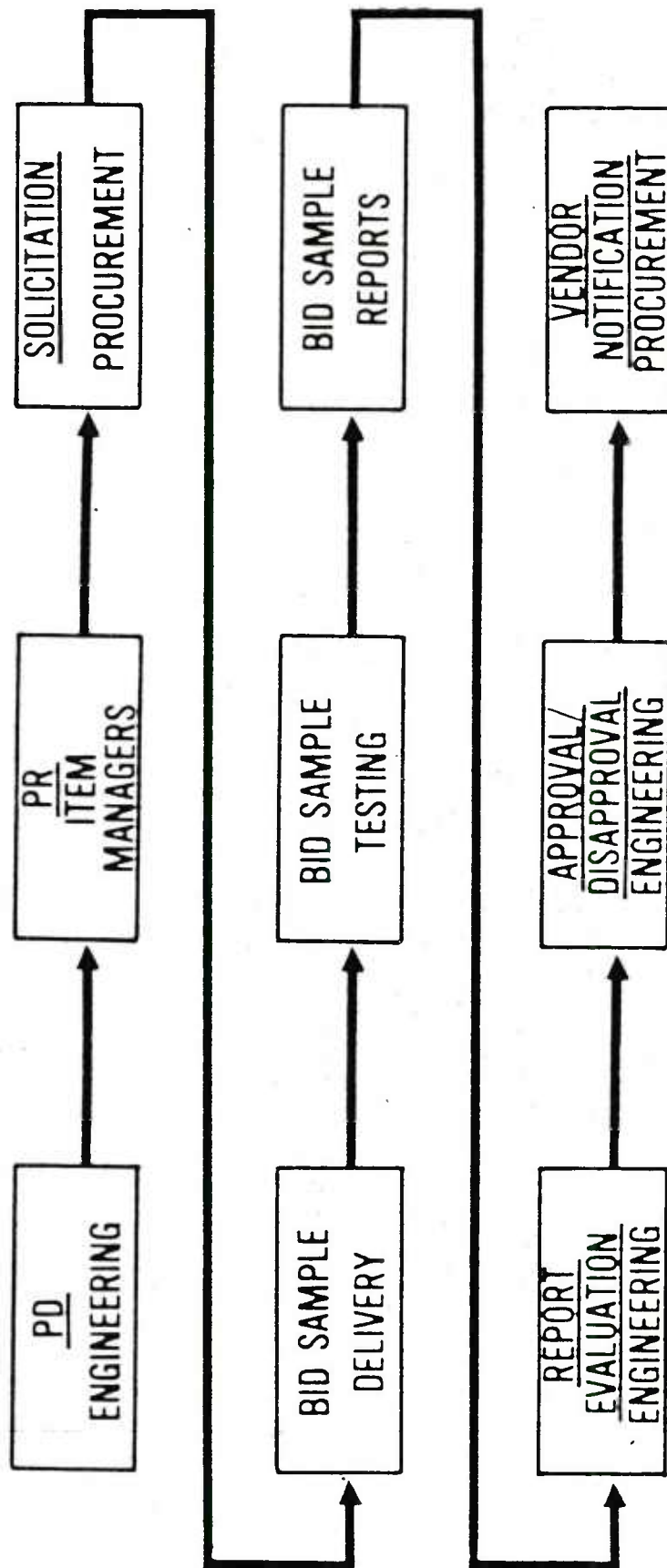
“STANDARDIZATION POLICIES, PROCEDURES AND INSTRUCTIONS.” IT IS DOD POLICY TO PROCURE COMMERCIAL ELECTRONIC TEST EQUIPMENT WHEN IT WILL MEET OUR REQUIREMENTS.

SA-ALC POLICY

- PURSUANT TO ASPR-2-202.4(B), THE EQUIPMENT OFFERED
MUST BE SUITABLE FROM THE STANDPOINT OF
“FACILITY OF USE”

BID SAMPLE CHANNELS

STEP 1



CHANNELS (CONT'D) STEP 2



8/ 05/

CHARACTERISTICS TESTED IAW MIL-T-28800

- PREOPERATIONAL INSPECTION
- OPERATING TEMPERATURE
- HUMIDITY
- LOW TEMPERATURE
- HIGH TEMPERATURE
- VIBRATION
- SHOCK PULSE
- BENCH HANDLING
- INPUT POWER CONSUMPTION

CHARACTERISTICS TESTED (CONT'D)

- VOLTAGE AND FREQUENCY VARIATION
- DIMENSIONS
- WEIGHT
- MECHANICAL STABILITY
- FRONT PANEL MARKINGS
- PERFORMANCE TESTS (GROUP A AND B)
- EMI RATIONALE

BID SAMPLE TESTING GUIDELINES

- VENDORS ARE NOT ALLOWED IN THE BID SAMPLE TESTING AREA AT ANY TIME.
- BID SAMPLE PACKAGE CONSISTS OF TWO INSTRUMENTS.
- EACH BID SAMPLE PACKAGE IS ALLOWED TWO (2) FAILURES.
- INSTRUMENTS ARE TESTED SIMULTANEOUSLY.
- FIRST FAILURE: TESTS ARE REASSIGNED TO OTHER INSTRUMENT.
- SECOND FAILURE: VENDOR REPAIRS ONLY ONE INSTRUMENT. REPAIRS WILL BE TO LOWEST DISCRETE COMPONENT.
- THIRD FAILURE: BID SAMPLE PACKAGE IS DECLARED UNACCEPTABLE

ADVANTAGES OF THE BID SAMPLE PROGRAM

- PROCURES COMMERCIAL ELECTRONIC
TEST EQUIPMENT WHERE POSSIBLE
- SAVINGS IN R&D
- INCENTIVE TO INDUSTRY
- INDUSTRY PARTICIPATION
- MAXIMUM USE OF FUNDS
- "FLY BEFORE BUY"
- BID SAMPLE DELIVERY: 5 TO 14 MONTHS
FIRST ARTICLE DELIVERY: 24 TO 50 MONTHS
- DOES NOT INFRINGE ON PROPRIETARY DATA
- MANUFACTURER DOES NOT HAVE TO "TOOL UP"
TO SUBMIT A BID SAMPLE

FUTURE PLANS FOR BID SAMPLE LAB

- **PROVIDE EMI FACILITIES IN CONJUNCTION WITH
MATE QUALIFICATION CENTER**

FIFB One Eleven AIS-R



Thomas F. Devlin
F-111 Program Manager
Westinghouse Electric Company

F/IB One Eleven AIS-R **BACKGROUND**



- **Air Force Inventory of 400 Aircraft**
 - 6 Different Configurations/Mission Design Series (MDS)
F-111A, FB-111, EF-111, F111D, F-111E, F-111F
- **F/IB-111 Series Constitutes:**
 - 19 % OF A.F. Fighter Aircraft
 - 20 % OF A.F. Bomber Aircraft
 - 100 % OF A.F. All Weather Attack Bomber Aircraft

F/1B One Eleven AIS-R
QUANTITY OF UUTs PER MDS



MDS	FB	EF	A	E	F	D
UUT's TESTED	182	123	132	127	131	141

FIFB One Eleven AIS-R

TYPES OF UUT'S SUPPORTED BY AIS



SYSTEM	TECHNOLOGY
RADAR ATTACK RADAR SYSTEMS APQ-113 APQ-114 APQ-130 TERRAIN FOLLOWING RADARS	RF, ANALOG
FLIGHT CONTROL GYROS ACCELEROMETERS COMPUTERS AIR DATA COMPUTER	LOW LEVEL ANALOG, DIGITAL, PNEUMATICS
NAVIGATION INERTIAL NAVIGATION SYSTEMS AJN-16 AJQ-20 ASTRO COMPASS ASQ-119 IFF ARX-76	OPTICS, ANALOG, RF
RADIO/COMMUNICATION HF ARC 112/123 ILS ARN-58 ARA-48	ANALOG, RF
ECM RWR ALR-62 JAMMERS ALQ-94 ALQ-137 TWS AAR-34 ALR-23	RF, ANALOG, INFRA-RED (IR)
OPTICAL SIGHTS/HUDES GENERAL PURPOSE COMPUTERS	OPTICS, VIDEO, ANALOG DIGITAL

DEV 4
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F/111 One Eleven AIS-R

F/111 PRESENT AIS VS F/111 REPLACEMENT AIS



BASE	F-111 MDS	EXISTING F-111 AIS TEST STATIONS		REPLACEMENT AIS TEST SYSTEMS	
		TYPES	QUANTITY	TYPES	QUANTITY
MOUNTAIN HOME	A	14	55	4	8
MOUNTAIN HOME	EF	*	*	4	4
PEASE	FB	12	15	4	8
PLATTSBURGH	FB	12	18	4	8
CANNON	D	9	56	4	12
LAKENHEATH	F	14	41	4	12
UPPER HEYFORD	E	14	39	4	12
UPPER HEYFORD	EF	*	*	4	4
CANNON (PROTOTYPE)	D			4	6
TOTAL SAC & TAC		27	224	4	74
LOGISTICS			100		20
TOTAL			324		94
*EF COMBINED WITH A/E FOR EXISTING AIS					

F/IB One Eleven AIS-R

SUMMARY OF MAJOR DELIVERABLE REQUIREMENTS



ILSD

- 22 Complete Intermediate Shops Consisting of
 - 25 Computer Test Stations
 - 22 Video Test Stations
 - 25 RF Test Stations
 - 22 EW Test Stations
- 94
- 3 Software Development Stations
- 183 TPS's
- 120 ITA Types

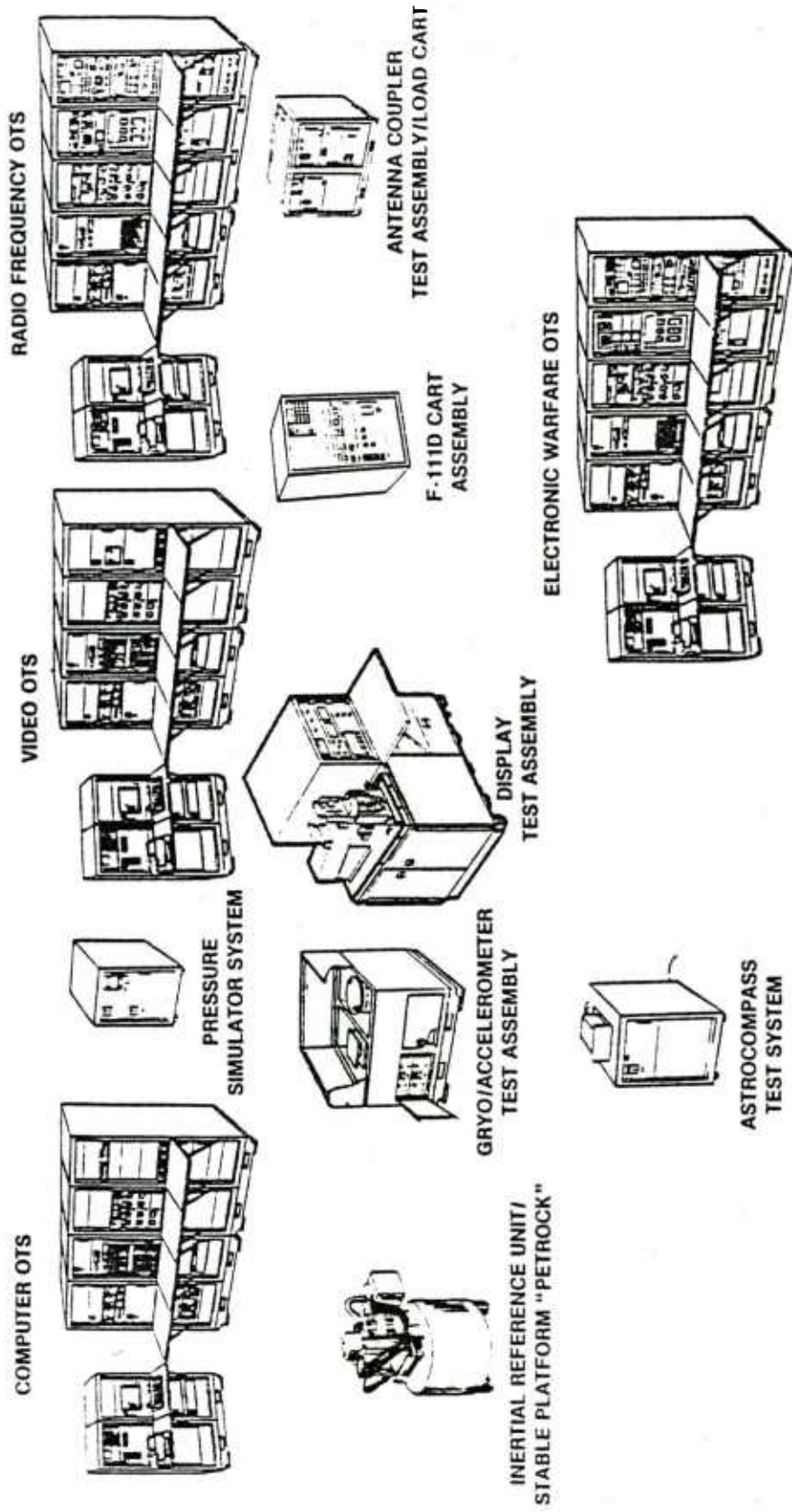
- Technical Manuals
- Technical Training
- 183 TRD's
- LSA Data
- Field Installation & Checkout
- Provisioning Data

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FIFB One Eleven AIS-R

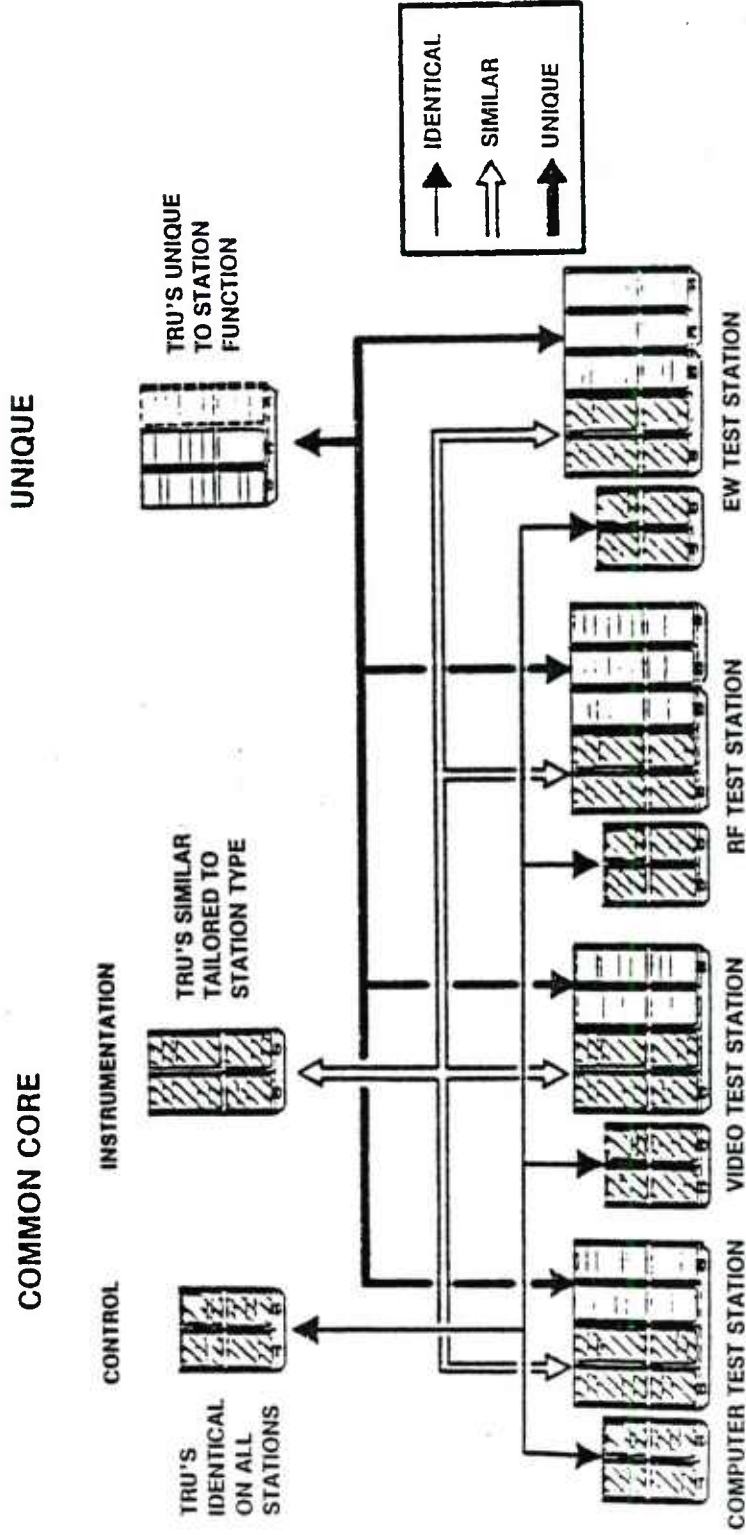


AIS REPLACEMENT TEST STATIONS [ILSD]



VIII-3
8 22 83

F/IB One Eleven AIS-R **F/IB-111 AIS MODULAR GROUPS**



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F/IB One Eleven AIS-R

CHARACTERISTICS



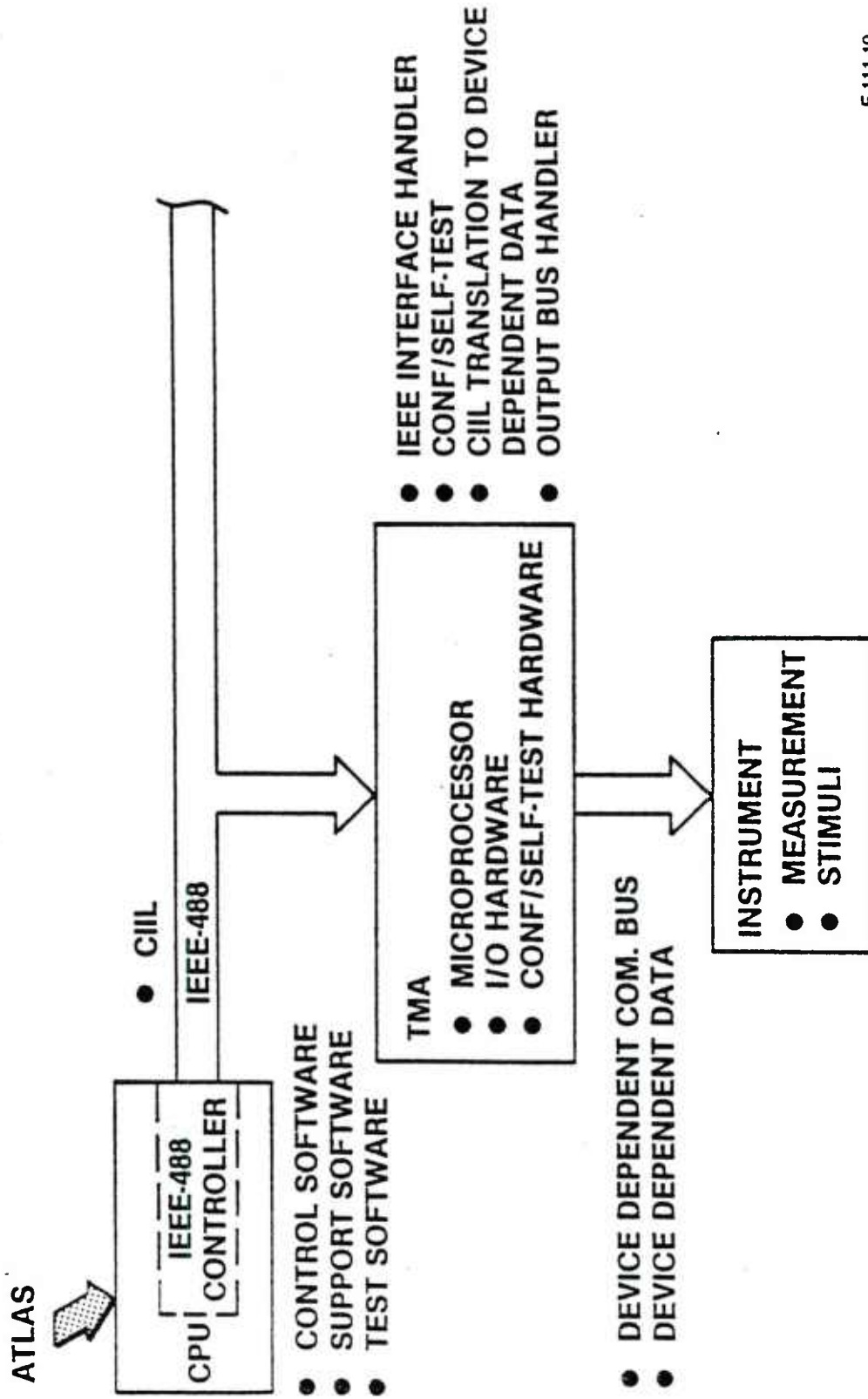
- EXISTING TEST METHODOLOGY
- PASSIVE INTERFACE TEST ADAPTERS
- UTILIZE PROVISIONED HARDWARE
- UTILIZE PROVEN SEASONED HARDWARE/SOFTWARE
- DISTRIBUTED PROCESSING
- DYNAMIC INTERACTIVE TRU TESTING
- ATLAS 716C
- IEEE-488
- MATE CIIL
- CENTRALIZED SWITCHING MATRIX
- FRIENDLY OPERATOR INTERFACE
- MAXIMIZED ATE SUPPORTABILITY
- EASY UPGRADING/EXPANSION
- EXISTING MATE MODULES

F-1115

F/IB One Eleven AIS-R SYSTEM ARCHITECTURE



ILSD



F-111-10

F/IB One Eleven AIS-R

TMA APPROACH



ILSD

<u>Station Type</u>		<u>Individual TMA</u>	<u>Total TRU Controllable Functions</u>
● Computer	T.S.	9	14
● Video	T.S.	12	15
● RF	T.S.	11	22
● EW	T.S.	12	23

FIFB One Eleven AIS-R
TEST PROGRAM SETS



MDS	FB	EF	A	E	F	D	TOTAL
UUTs TESTED	182	123	132	127	131	141	303
TPS DEVELOPED	95	40	12	0	9	27	183

F/IB One Eleven AIS-R
CROSS TEST STATION TESTING



ILSD

UUT's	COMPUTER	VIDEO	RF	EW
41	X	X		
33			X	
46				X
38	X	X		
23	X	X	X	X
122				
303	186	178	168	160

F/IB One Eleven AIS-R



ILSD

SUPPORT FEATURES

- SELF TEST
 - CONFIDENCE TEST
 - IN PROCESS SELF TEST
 - OAFI
- PATEC CALIBRATION
- OPERATION/MAINTENANCE SAME PERSON
- INTERCHANGEABILITY
 - OPERATOR CONSOLE
 - TRU'S
 - SRU'S
- PASSIVE ITA'S

F/IB One Eleven AIS-R

SELF-TEST



ILSD

- SELF-TEST ITA'S
- FAULT DETECTION - 100%
- FAULT ISOLATION TO TRU - 100%
- FAULT ISOLATION TO 2 SRU - 95%
- FAULT ISOLATION TO 1 SRU - 90%

F-111-29

FIFB One Eleven AIS-R

SUMMARY

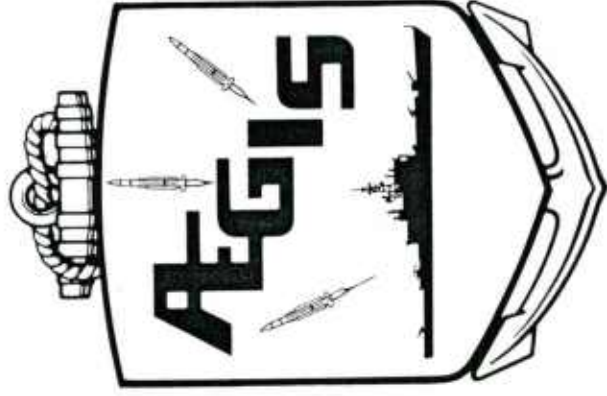


ILSD

F/FB-111 AIS REPLACEMENT PROGRAM

- ON TIME
- REDUCED TEST STATION TYPES
- REDUCED NUMBER OF TEST STATIONS NEEDED
- IMPROVED UUT FAULT DETECTION/ISOLATION
- INCREASED AVAILABILITY
- INCREASED SUPPORTABILITY
- 30% GROWTH
- MANY MATE FEATURES
- DESIGN CONSIDERED AMP AND OTHER FUTURE UUT'S
- WILL NOT NEED REPLACEMENT AGAIN

F-111-31

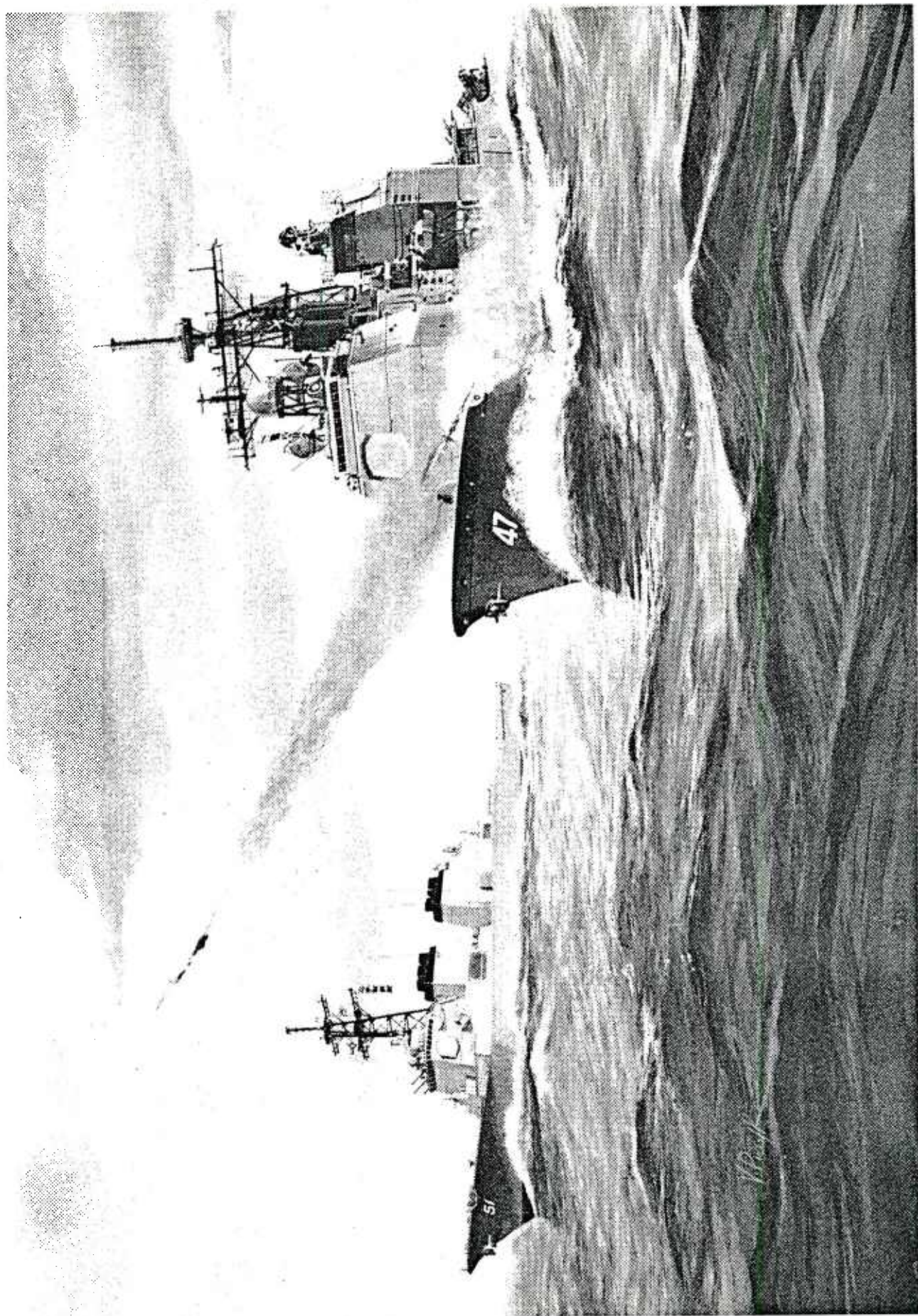


USN AEGIS TEST EQUIPMENT PROGRAM

R. McKee

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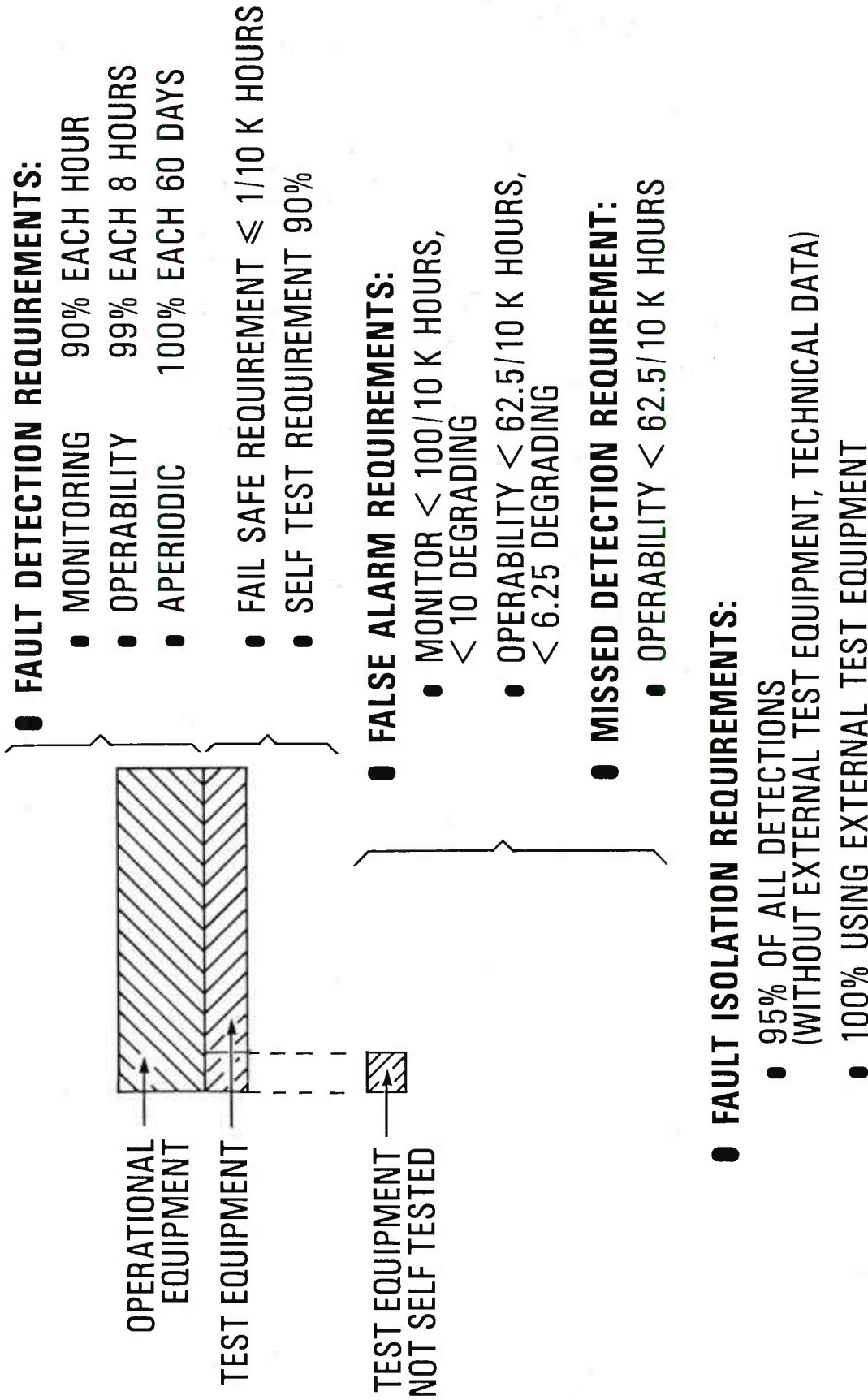


DDG 51 COMBAT SYSTEM READINESS/MAINTENANCE TEST

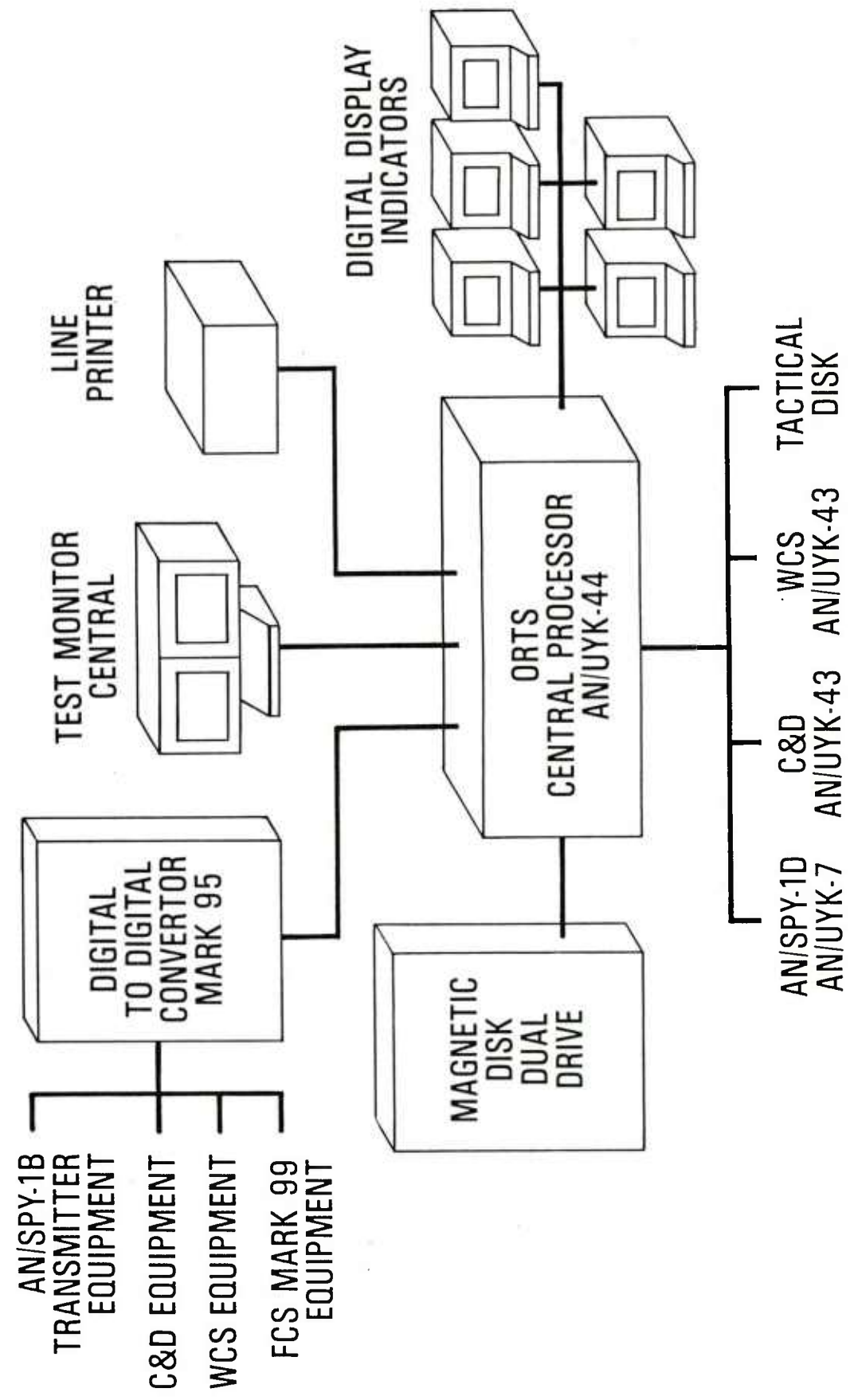
- **OBJECTIVE**
 - SUPPORT MISSION READINESS
 - SUPPORT MAINTENANCE READINESS
- **CHARACTERISTICS OF TEST AND MAINTENANCE**
 - AUTOMATIC FAULT DETECTION/ISOLATION AND STATUS DISPLAY
 - RAPID AUTOMATIC RECOVERY FROM EQUIPMENT AND COMPUTER PROGRAM FAILURES
 - CENTRALIZED CONTROL OF TEST ACTIVITY THROUGH COMBAT SYSTEM MAINTENANCE CENTRAL
 - CONTROL OF AWS MARK 7 TEST THROUGH ORTS TEST MONITOR CONSOLE
 - FOR NEW EQUIPMENT, LRU DETERMINATION ESSENTIALLY WITHIN CABINETS FOR EQUIPMENTS: i.e., AN/SPY-1D
 - CARD-BY-CARD REPLACEMENT AND RETEST
 - MICROFICHE PROCEDURES SUPPORTING REPAIR AND RETEST

AEGIS WEAPON SYSTEM FAULT DETECTION/ISOLATION

Top Level Requirements — New Equipment

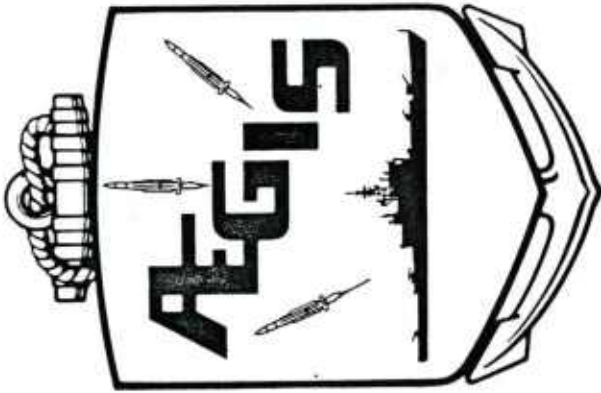


DDG 51 CLASS OPERATIONAL READINESS TEST SYSTEM



FUTURE POSSIBILITIES FOR SUPPORT EQUIPMENT

- SCHEMATICS RESIDENT ON DISKS, WITH SECTIONS KEYED TO APPLICABLE FAULT IDENTIFICATION NUMBERS
- BUILT IN MICROCOMPUTERS AT CABINET LEVEL, WITH STANDARDIZED INTERFACES/DATA FORMAT FOR MODULAR SYSTEM CONSTRUCTION
- SHORE TO SHIP (OR REMOTE SITE) UPDATE OF MAINTENANCE DATA VIA SATELLITE
- SHIPBOARD (OR REMOTE SITE) TV CAMERAS WITH LINK UP TO SHORE FOR REAL-TIME FACTORY SUPPORT OF ORGANIZATIONAL LEVEL MAINTENANCE PROBLEMS
- ESTABLISH TEAMS OF SUPPORT EQUIPMENT DESIGNERS/PRIME EQUIPMENT DESIGNERS FOR CONCEPT/DEVELOPMENT OF NEW SYSTEMS

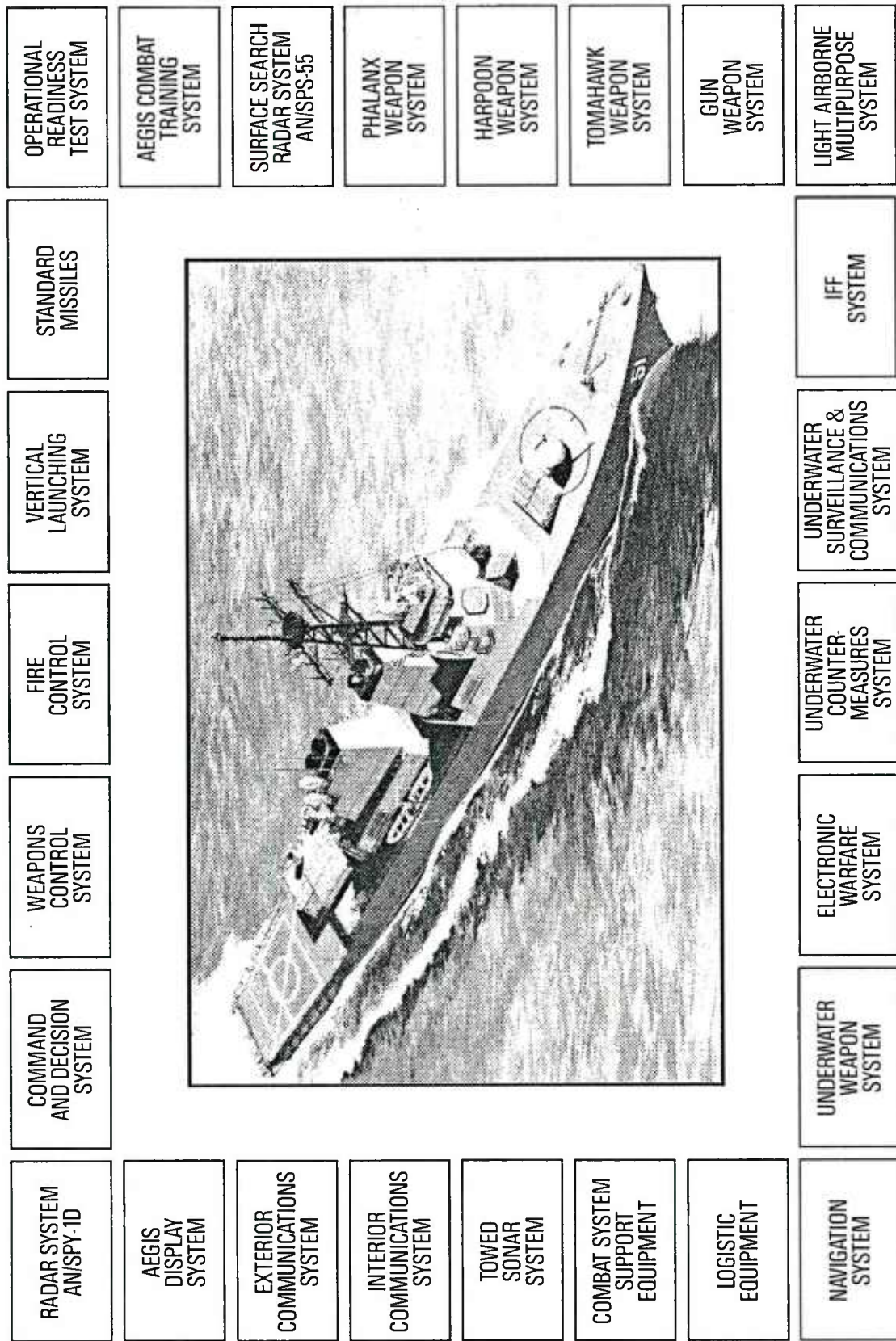


DDG 51 COMBAT SYSTEM TEST EQUIPMENT

T. O. Vinson

RCM Missile and
Surface Radar

DDG 51 COMBAT SYSTEM ELEMENTS



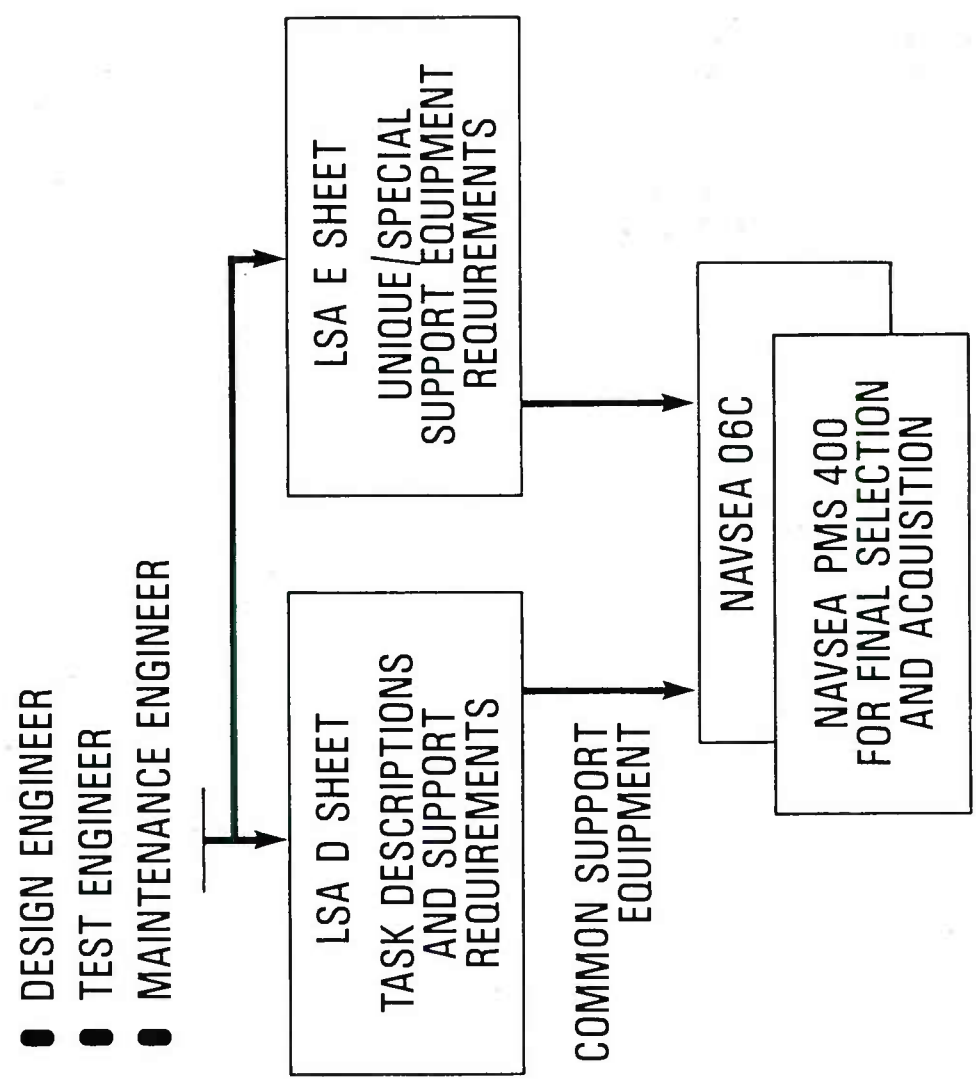
AEGIS SUPPORT EQUIPMENT

- THREE TYPES:

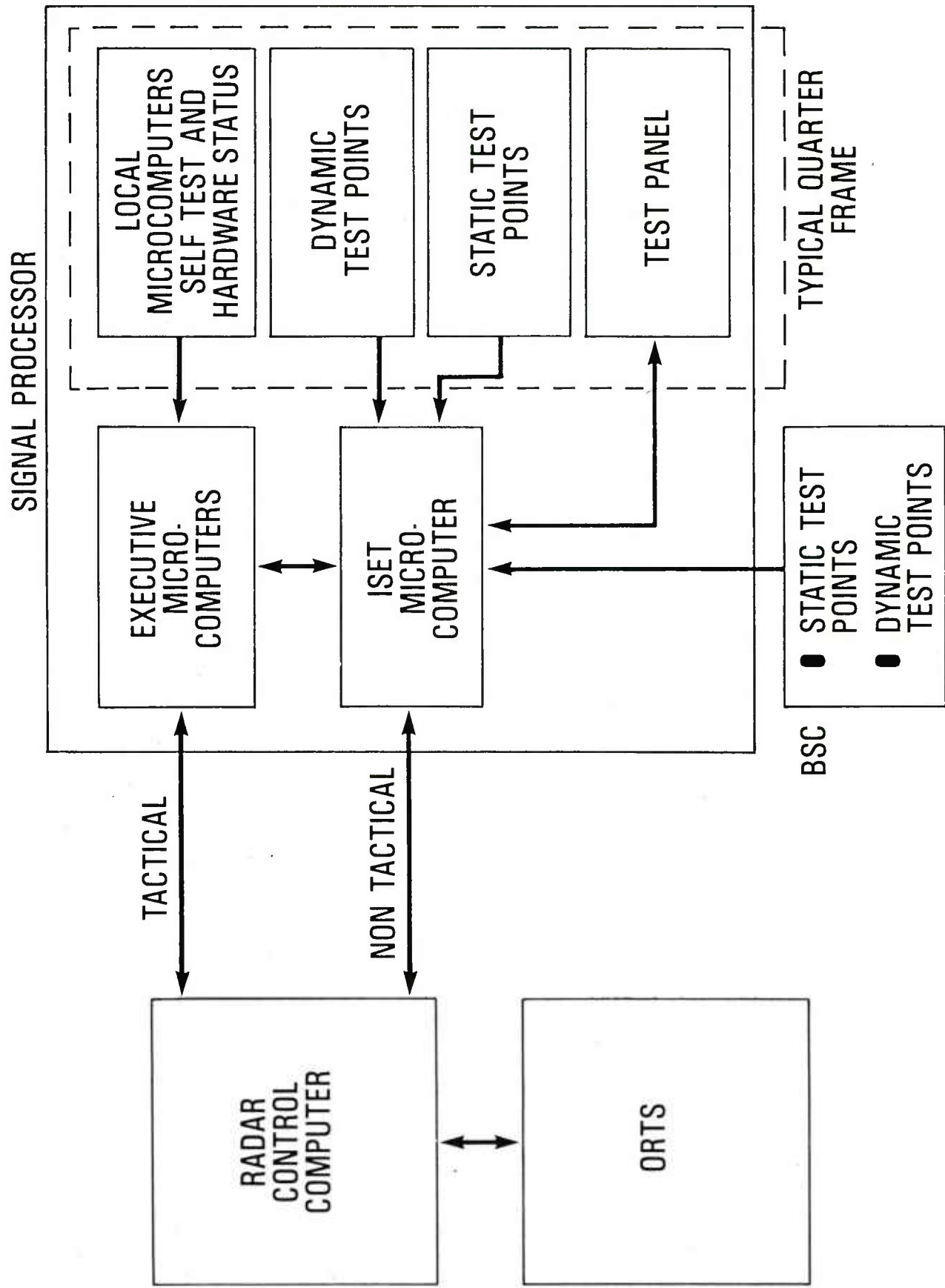
- A. AUTOMATIC TEST EQUIPMENT (ATE)
- B. BUILT IN TEST EQUIPMENT (BITE)
(REQUIRES OPERATOR INVOLVEMENT)
- C. PORTABLE TEST EQUIPMENT

ATE AND BITE MUST ISOLATE 95% OF FAILURES

PORTABLE TEST EQUIPMENT ID/SELECTION



ISSET SUBSYSTEM CONFIGURATION



ADVANTAGES OF CABINET LEVEL MICROCOMPUTERS

- DESIGN ENGINEERS INVOLVED FROM CONCEPT TO FACTORY ACCEPTANCE TESTS
- ELIMINATES LARGE SOFTWARE DEVELOPMENT/DEBUG EFFORT; FAULT LOGIC IS BUILT IN
- BITE VERIFICATION PROCEEDS WITH PRIME EQUIPMENT VERIFICATION

TEKTRONIX CUSTOMER SERVICE

LONG-TERM PRODUCT SUPPORT AT TEKTRONIX

Walter Karsted
Tektronix, Inc.

LONG-TERM PRODUCT SUPPORT

**A FORMAL PROGRAM
TO CONTINUE
OFFERING CUSTOMERS
UNMATCHED VALUE IN
SERVICE**

TEKTRONIX CUSTOMER SERVICE

LONG-TERM PRODUCT SUPPORT

Corporate-wide integrated program

Main features

- Maintenance repair
- Replacement parts
- Accessories
- Calibration fixtures
- Technical support
- Technical publications
- Product status information
- Manufacturing rights
- Defined time phases

TEKTRONIX CUSTOMER SERVICE

LONG-TERM PRODUCT SUPPORT

Defined phases

**Phase I: First six years
Full support**

**Phase II: Seventh through ninth year
Limited**

**Phase III: After ninth year
Obsolete**

TEKTRONIX CUSTOMER SERVICE

LONG-TERM PRODUCT SUPPORT

Phase I

First six years after phase out

- Maintenance repair at authorized world-wide network of service centers. Labor rates the same as current products.
- Replacement parts, accessories, and calibration fixtures available.
- Technical information available in hardcopy or microfiche.

TEKTRONIX CUSTOMER SERVICE

LONG-TERM PRODUCT SUPPORT

Phase II

Years seven through nine after phase-out

- Maintenance service may be limited to designated service centers.
- Replacement parts will be stocked according to demand and vendor availability.
Prices will reflect the increase in costs of procurement and/or custom manufacturing.
- Accessories and calibration fixtures specific to discontinued products may no longer be available.
- Technical data available in hardcopy and microfiche.

TEKTRONIX CUSTOMER SERVICE

LONG-TERM PRODUCT SUPPORT

Phase III

Nine years after phase-out

Product considered obsolete

- Technical support available on a “best effort” basis.
- Product-specific parts will not normally be stocked.
- Technical information will be available for another six years.
- Manufacturing rights may be made available.

Decision based on Tek ability to provide adequate documentation and item is not proprietarily sensitive.

TEKTRONIX CUSTOMER SERVICE

LONG-TERM PRODUCT SUPPORT

Normal product support intent is nine (9) years, but exceptions are:

- A. Teleequipment products receive six (6) year support.**
- B. Some OEM products receive six (6) year support.**
- C. Some probes, accessories, and calibration fixtures receive six (6) year support.**
- D. When a vendor is unable to provide required replacement items or raw materials, and product re-engineering or modification is deemed impractical.**
- E. Products with a reduced or special support period.**

TEKTRONIX CUSTOMER SERVICE

LONG-TERM PRODUCT SUPPORT

Phase-out documentation

“Tektronix products in long-term support”

- Lists products by phase
- Defines last year of support

Intent to aid customer in replacement and support decisions.

TEKTRONIX CUSTOMER SERVICE

LONG-TERM PRODUCT SUPPORT

Product support program

Tektronix intends to provide support, including maintenance service and replacement parts, for at least nine (9) years after phase-out of the product line.

Tektronix may occasionally decrease the product support period and/or level of service when vendors are unable to supply required replacement items or raw materials, and product re-engineering or modification is deemed impractical.

Product technical information, on microfiche, will be supplied by Tektronix for at least fifteen (15) years after phase-out of the product line.

TEKTRONIX CUSTOMER SERVICE

LONG-TERM PRODUCT SUPPORT

Potential impacts on long-term support

- Software
- Last-time buys
- Rapid technological changes shorten product life

LONG-TERM PRODUCT SUPPORT

**A PROGRAM DESIGNED TO
PROTECT THE USE OF TEK
PRODUCTS OVER THEIR
EXPECTED LIFE**

ADPA ANNUAL REVIEW

THEME PRESENTATION

SUMMARY:

The need for the ETE Industry to respond to the Emergency Defense Market was made very evident by technical and logistic support requirements of the two DOD Weapon Systems discussed in Session III. This was amplified by Commodore Simon's comments on the future technology needs by C³ in the Navy.

The speakers representing the Commercial ETE Industry presented us with the measurement and business challenges, as well as their measurement solution for the Emerging Defense Requirements. In summary, we are committed to meet this challenge.

Tom Strasser
Chairman
Theme Presentation

AMERICAN DEFENSE PREPAREDNESS ASSOCIATION TALK
MAY 10-11, 1984

It is a pleasure for me to be able to participate in this 1984 Annual Program Review of the Electronic Test Equipment Division of ADPA.

This is indeed a challenging and exciting time for the test equipment industry. In my 25 year association, I cannot recall a period as dynamic as the present. The Test Equipment Industry has grown to a very respectable size. This year, I estimate a Western world market of about \$10B with a growth rate in the neighborhood of over 20%.

Test and measurement equipment, along with the rapidly growing computer-aided design business, have collectively been called the "Machine Tools of the Electronic Industry." It is little wonder then that the test and measurement growth rate is so high and has reached such important proportions.

The broader electronic industry has become, without a doubt, the most important industry of our time. My estimate for the size of the greater electronics industry falls between one-third and one-half of a trillion dollars for equipment consumption in the countries we normally consider friendly and who we recognize as good trading partners. Furthermore, I believe one could make a case that job formation that is directly a consequence of the growth in the electronics industry will more than account for the total net new job formation in the United States for the past ten years. This, of course, is spearheaded by the massive increase in information-centered jobs that are enabled by the spectacular developments in computers and communications. Electronics is a vital industry to both the economic well being and security of our country.

The Electronic Test Equipment Industry is proud of the role it has played in this phenomenal development. Even though we only represent about 2% of the total electronics industry, the role played in supporting the technology developments is fundamental to any growth or progress at all. Also, of course, the manufacturing and support roles are equally important.

The US Defense electronics consumption represents at some \$37B about 7 to 10% of the total, coming in at fourth place behind Data Processing, Communications, and Consumer Electronics.

The US Defense program represents a special challenge and in some sense a dilemma to the Electronic Test Equipment Industry. In most ways, the Defense requirements exactly parallel the civilian or commercial market. The demands for lower cost, better performance, higher reliability, ease of use, and better maintenance and repair services are really no different.

On the other hand, defense requirements tend to push hard on advanced technical and performance capabilities. This follows from the basic US Defense strategy of Early Threat Detection followed by appropriate counter measures. This leads to the perpetual cycle of threat/response, threat/response. This demands better technology and capability - more accuracy, better resolution, lower noise, wider bandwidths, higher frequencies, faster logic, larger memories, higher densities, as well as greater reliability.

The government regulations and procurement practices also make the government far and away the most difficult customer to serve and do business with. I will develop this point a bit more later on.

First, let me develop the importance of a very positive relationship between industry and government:

There is the issue of cost. The United States Test Equipment Industry is very competitive on a worldwide basis. Perhaps the best proof of this is the fact that the US Electronic Test Equipment Industry is still a very large net exporter (Electronics magazine estimates \$1B net) in spite of strong international competitors, a strong dollar which makes our products less competitive overseas, and a very strong nationalistic, buy local, pressures in the major markets of Europe and Japan.

Second, there is the issue of technology insertion. The Test Equipment Industry is spending close to \$1B on R&D. This is company-funded R&D primarily from funds generated by commercial sales to commercial customers. That R&D has led to some very important developments that are fundamental to our progress and leadership in defense systems. In fact, we generally use commercial customer revenues to develop products to meet military performance requirements.

Third, there is the issue of quality. During the past five years the US electronic industry has enjoyed a renaissance in quality. I have spoken previously on this subject relative to the US semiconductor industry and the progress they have made. In many ways, this quality renaissance was in response to the great progress that was made in Japan as they implemented the methods of statistical quality control and total quality control that Japanese companies developed under the tutelage of several esteemed United States quality experts including Dr. W. Edwards Demming and Dr. Joseph Juran.

The technique of statistical quality control calls for systematic, continuous progress as more and more products are produced. Plotting failure rates, using process control limits, using Pareto chart analysis and continuously improving the process leads without failure to ever improving product quality.

A corollary observation is the expectation that quality should improve as more units are produced if industry is systematically applying these methods of statistical quality control.

For example: We have been working hard at our company to make SQC and TQC a way of life. I recently looked at the quality record of seven major microwave instruments produced in three different Hewlett-Packard divisions. I found that on the average we were making an improvement (reduction) in failure rate of 25% every time we doubled the number of cumulative units produced. The range, by-the-way, was 17% to 41%. This means that a product with a manufacturing history in the neighborhood of 10,000 units would have an expected failure rate five to six times lower than a product whose production life was limited to perhaps 100 units. I conclude that there is a profound quality and reliability advantage to the broadened use of high volume commercial test equipment in support of the defense systems of this country. This is the most basic element in life cycle cost.

Fourth is support. The Test Equipment Industry through scale has developed one of the best, most responsive, most enduring, and most cost effective repair, part replacement, and support infrastructures in the world. I believe our industry can, has, and will respond effectively to the requirements of long support life for instruments and systems to support the defense infrastructure and do it in the most cost effective way possible.

I would like now to highlight one special challenge that we face in the test equipment business. This \$10B industry is not unnoticed in other countries. Not only has it become an attractive business, governments have recognized its fundamental importance to advancing their technology base and their participation in the vital, growing electronics industry.

In some cases, foreign companies are so intent on entering the market that they are looking for new ways to improve engineering productivity. As with the case of quality, they are looking to leaders in US industry. For example, we have a case where a non-US competitor copied one of our products to the extent that where a custom value resistor was used by Hewlett-Packard, this organization substituted two resistors in series to realize the same value. This company also copied the Hewlett-Packard data sheet word for word. That surely saves translation costs. Clearly, they were not contributing their own engineering but just lifting another company's design contributions. There are other well known cases where personal computers were actually counterfeited and sold using the original company's trademark.

This is a difficult problem for our industry. We must move aggressively to protect our proprietary developments from copy even if in some cases it means refusal to do business under certain terms and conditions. For example, the recent media flap on spare parts procurement is leading to a lemming rush to develop laws and regulations concerning data rights and manufacturing processes. While we support the move to find ways to stimulate true competition, laws on data rights will not accomplish this goal. With international competition that will copy data sheets and circuits, even to the extent of doing something silly, it is unacceptable to ask industry to make data rights and manufacturing know-how available when these products, data, and know-how were developed at the manufacturers' own expense. Such a move will cause suppliers to withdraw their most technically advanced and best products from the defense market in the interest of protecting their position in the broader market

place. This will reduce competition, quality, and technology insertion to a disastrous extent.

Well, these are some of the challenges that I see. As an industry we stand ready to invest our own resources to advance technology to meet the ever increasing demands of industry and defense. We stand ready to meet the demands for better quality, lower cost, and better and longer term support. We also expect to be responsible partners on issues such as I mentioned. However, we expect to maintain and improve our position of worldwide leadership and competitiveness. We ask only that both the government customer and industry understand that this leadership is fundamental to our continued mutual progress.

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NEW MEASUREMENT SOLUTIONS IN THE MICROWAVE INDUSTRY

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I. INTRODUCTION:

Microwaves cover the frequency range from about 1 GHz up into the hundreds of GHz where finally optical systems replace the traditional microwave systems. It is obvious to anybody that the frequency coverage of more and more systems is moved up in frequency due to the overcrowding at the lower frequencies, whether these systems are communication systems, radar systems, ECM systems, guidance systems, or navigation systems, etc. Therefore, microwave measurements play an ever increasing role in the test and troubleshooting requirements of newly developed military systems, and the question should be asked: "Can the microwave industry satisfy the microwave measurement requirements of today's systems, and what are the prospects of satisfying the measurement requirements of future systems?"

Before describing the individual microwave instruments, their accuracy, speed of measurements, etc., let me make an overall statement. Due to the intense competition in the commercial instrument industry, the presently available microwave instruments are so advanced that they satisfy very probably all the measurement and test requirements of present military microwave systems. I furthermore state with confidence, that the development capability

of the present microwave instrument industry is strong enough so that if a system needs a new instrument (a microwave synthesized signal generator, for instance, for a higher frequency range), this new instrument is available before, or at least at the same time, the new system can be tested.

Now let me discuss in detail the type of measurements which have to be made at microwave frequencies, and what techniques and what instruments are needed.

We divide microwave instrumentation into five classes:

- A. Instruments to measure the basic quantities at microwave frequencies: Power (power level in dBm); frequency (in MHz, GHz, or period in μsec , nsec); impedance (measured as reflection coefficient against a perfect transmission line which by definition has a characteristic impedance given in ohms), noise (expressed in excess noise ratio relative to KTB), insertion loss or attenuation (expressed in dB).
- B. Network Analyzers to measure the linear (or at least linearized) coefficients of a microwave network.
- C. Waveform Analyzers to analyze either generated or received signals. At microwave frequencies, they are mostly spectrum analyzers; in addition, we group here modulation meters, microwave Fourier Analyzers, or microwave oscilloscopes.
- D. Signal Generator; to simulate any microwave signal which might be generated by a system, or which might be received by a system, or which might be necessary for a certain measurement technique.

E. Instruments for measuring interfering signals (fields, voltages, currents) or for generating interfering signals for susceptibility measurements.

There are two classes of transmission lines which are used at microwave frequencies: Coaxial transmission lines, and waveguide type transmission lines. All general purpose instruments use coaxial connectors as input or output connectors, since the coaxial line supports the TEM mode, and therefore has a frequency range from DC to f_{\max} which is

$$f_{\max} = \frac{c}{\pi \times r_o \sqrt{\epsilon_r} \left(1 + e^{-\frac{50 \sqrt{\epsilon_r}}{60}} \right)} \quad \text{Hz}$$

where:

c = speed of light = 3×10^8 m/sec

r_o = Radius of inside of outer conductor

ϵ_r = Relative dielectric constant of area between inner and outer conductor.

It is interesting to note that the frequency expansion in the microwave industry is very closely related to the development of mechanically reliable, low VSWR coaxial connectors. The main coaxial connector in the 50's and 60's was the type N connector (and its improvement) which is designed for a coaxial transmission line with an I.D. of the outer conductor of 7 mm. Its maximum frequency, above which higher order modes can occur, is 19 GHz. Therefore, 18 GHz became the highest frequency of the major microwave activities. Then in the later 60's, the SMA connector with its associated semi-rigid, teflon filled transmission line (I.D. of

outer conductor 4.1 mm.) became popular; and subsequently, the microwave frequency range expanded to 26.5 GHz. Now, new, reliable, low VSWR coaxial connectors are appearing commercially which work with a teflon foam filled 2.4 mm. transmission line, which have a maximum operating frequency of 46 GHz. We will soon see the start of the expansion of microwave activities beyond 26 GHz, up to 46 GHz.

There is still a place for waveguide systems and components especially for higher power application, and for the millimeter wave frequency region. However, the use of waveguide flanges on microwave instruments is disappearing and will be only used on special instruments.

Before I will discuss the characteristics of the individual instruments as they exist today, and of the instruments which most probably will be available in the next few months or years, let me voice a concern about a serious problem facing the microwave instrument industry: Need for improved microwave Standards. As you all know, the accuracy of every microwave measurement has to be traceable to a National Standard. The need for this traceability was really recognized by the military, and by Congress, during the time period when the U.S. was not able to place a satellite into orbit after Sputnik #1. The National Bureau of Standards in Boulder, Colorado undertook the task to develop up-to-date microwave standards, and really succeeded, in my view. They

assembled an excellent team of scientists and engineers, and came up with standards such as the Tuned Reflectometer for Impedance Standardization, Microcalorimeters for Power Standards, Atomic Clocks for Time and Frequency Standards, contributed to the development of precision connectors and so on. Today, only a very small group of people work on microwave standards at NBS, Boulder, limping along on a very small budget, contributing very little to the advancement of microwave standards. I, therefore, joined in March 1984 a MTT-S AdHoc Committee called "To promote National Microwave Measurement Standards" to impress the Congress that "the U.S. Microwave Industry, as well as the Department of Defense, are most dissatisfied with the support received by the National Bureau of Standards in the development of better primary Standards for radio frequency and microwave measurements" (quote from 2/17/84 letter of Dr. B. Weinschel, the Vice-Chairman of this AdHoc Committee to the Honorable George E. Brown of the U.S. House of Representatives).

II. Description of Instruments to Measure the Basic Quantities at Microwave Frequencies

In order to avoid any unintended endorsement, I will discuss instruments only generically, not by manufacturer and model number. I should add, however, that the Electronic Instrumentation Division of the Eaton Corporation for whom I work, pays the expenses of my trip here.

- A. Power meters for measuring levels directly between +20 dBm and -30 dBm use almost exclusively thermocouple type power sensors which can be calibrated to accuracies of $\pm 2\%$. Their VSWR is

quite good (typically 1.1 up to several gigahertz, 1.25 at 26 GHz). Stability excellent. The power level indicators add an additional error of about 0.1% to 0.5%. The problem with these power sensors is that they are slow, and it takes typically 1 to 10 seconds to get an accurate reading.

For fast power level measurements, diode detectors have to be used, which have higher inaccuracies ($\pm 5\%$), and higher VSWR (1.3 - 1.5). The trend is for wider frequency range (widest 10 MHz - 26 GHz), better VSWR, linearity, stability. For low power levels (-30 dBm to -100 dBm), measurement receivers have to be used. These are very sophisticated power ratio meters with accuracies of better than ± 0.01 dB/10 dB of power variation.

- B. Frequency Meters today use exclusively microwave counters, which are down-converting microwave receivers where the instrument calculates the frequency by measuring the (low frequency) local oscillator frequency and the IF frequency. Accuracy depends nearly exclusively on the built-in frequency standard (typical accuracy 0.1 ppm). The newer frequency meters have wider frequency coverage (1 Hz to 44 GHz), better sensitivity (-30 dBm or better), and better reference frequency accuracy.

- C. Impedance meters at microwave frequencies are made by measuring the reflected signal, since the relationship

$$Z_x = Z_0 \frac{1 + \Gamma_x}{1 - \Gamma_x}$$

uniquely ties the unknown impedance Z_x to the reflection

coefficient Γ_x , provided that Z_0 is known accurately. Z_0 is realized by a low-loss air-filled transmission line, since impedance is really a mechanical quantity. To measure reflected signals, a directional component is required to separate the reflected signal from the incident signal. Either directional couplers or reflection bridges are used, with the bridges being more and more preferred due to their wide frequency coverage (widest 10 MHz to 26.5 GHz). The indicating instrument is an amplitude-only network analyzer, the generator usually a sweep generator. The trend is to even wider frequency range (up to 40 GHz), better accuracy, better reference line, faster measurements.

- D. Noise itself is usually not measured, but noise figure. Although there is no microwave noise figure meter available as such, there are new automatic RF noise figure meters with excellent accuracy (± 0.05 dB NF), which are used with a down-converting (linear) mixer, and a good (preferably synthesized) local oscillator.

There are new solid-state noise generators available which cover 10 MHz - 26.5 GHz, with a nominal ENR of 15.5 dB, and excellent VSWR. Since ENR accuracy is a direct error source in noise figure measurements, a continuous, inexpensive, and accurate (.02 dB) ENR calibration service should be made available. Trend is to push the automatic, low VSWR, wide gain range noise figure meter further up into the microwave region.

E. Insertion loss measurements at microwave frequencies is an important requirement, although insertion loss per definition is not an absolute quantity. Amplitude-only network analyzers with diode detectors and sweepers are used almost exclusively, the newer ones being programmable, and calibration routines are available to check their accuracies.

III. NETWORK ANALYZERS

The network analyzer is becoming more and more the basic measurement instrument for the linear properties of microwave networks. Assuming a two-port, the 4 scattering parameters S_{11} , S_{12} , S_{21} , and S_{22} totally describe the linear behavior of the two-port. One can calculate insertion loss, insertion gain, maximum available gain, attenuation, input and output VSWR, etc. from these four parameters. The newest network analyzer covers the frequency range from 45 MHz to 26.5 GHz. Although the basic accuracy is not too great, built-in calibration procedures allow accuracies which approach those of microwave standards. This network analyzer even contains an inverse Fourier Transformer Program which calculates the output time response to a (perfect) input step or pulse response, essentially acting as a very wideband Time Domain Reflectometer. This allows not only to locate excessive reflections in a microwave network, but also to evaluate the nature of these reflections.

The network analyzers presently commercially available are all receiver types which down-convert the RF signal from the measurement point to a low IF frequency and compare it to a coherent down-

converted reference signal. The comparison consists of a ratio measurement of the amplitudes and a phase shift measurement of these two low frequency signals. Since all scattering coefficients are complex ratios, the instrument will take the two measured quantities and convert them into their appropriate complex ratios. A new type of network analyzer was developed by the National Bureau of Standards in Boulder. It is called a six port, since it requires usually six level measurements to determine two complex ratios. The advantage of the six port is that it requires only the measurement of real quantities (level measurements with diode detectors). and therefore, its frequency range is restricted only by the availability of microwave components and detectors. The disadvantage of the six port is that the DC reading of the detectors have no relationship to any quantity to be measured and, therefore, no manual operation without the use of a computer is possible. The accuracy of the six port again will be as good as its calibration routines which in turn depend upon the mechanical accuracy of a reference air line, of a perfect short, and a defined open, the same items which are used for the calibration of the receiver type network analyzer.

The importance of network analyzer was realized by the Instrumentation Measurement Society of IEEE which in one of its technical subcommittees developed a standard for network analyzers. This standard is presently at the IEEE Standards Board for approval, and should be available in about six months.

IV. Waveform analyzers to analyze either generated or received signals.

As mentioned before, at microwave frequencies these are mostly spectrum analyzers, and we will discuss here only spectrum analyzers. The type of spectrum analyzer which we describe here is the sweeping receiver, although we have come a long way since the panoramic receivers of the early fifties, and many microwave spectrum analyzers are available, there is still a lot of improvement desired, especially in the analog portion of the spectrum analyzers. One of the most important specifications in a spectrum analyzer is the so called dynamic range, which is the maximum ratio of two signals which are simultaneously present at the input, and which can be measured to a specified accuracy. This range is limited at the low end by the noise figure of the spectrum analyzer, and at the high end by the compression. Microwave spectrum analyzers up to now use harmonic mixing which means that outside of the fundamental frequency mixing range (typically 2 to 6 GHz), the noise figure of the spectrum analyzer increases and the 1 dB compression point decreases both lowering the dynamic range. At the high frequency end of a microwave spectrum analyzer, noise figures of 50dB and higher are not uncommon.

The modern spectrum analyzer should use fundamental mixing using a high level local oscillator signal to not only decrease the conversion loss of the receiver (which decreases the noise figure), but also increases the intermodulation intercept point of the receiver which increase the dynamic range. It, furthermore, should contain an RF and microwave filter in the input circuit,

sweeping along with the local oscillator to avoid overloads and unwanted intermodulation products by signals outside of the display range. Right now, only microwave YIG filters are used which do not extend beyond 22 GHz at the high side, and 2 GHz on the low side. Furthermore, the modern spectrum analyzer should extend up to 26.5 GHz to be compatible with other modern microwave test equipment. The spectrum analyzer is becoming one of the most important microwave measurement instruments: It can measure the amplitude of a signal provided the analyzer gain is properly calibrated; it can measure the frequency of a signal provided the local oscillator frequency is accurately known; it can measure power ratios accurately if the Logarithmic amplitude characteristic is well-known. It can measure distortion by measuring harmonics. It can measure pulse, frequency, and amplitude modulation as long as the scan width is accurately calibrated. It can also be used as a standard measurement receiver provided again it has accurate amplitude calibration. It should also have a spectrally clean enough set of local oscillators that the close-in noise, residual fm, incidental am, and fm on unknown signals can be properly determined.

Looking at these requirements, we can say that the present spectrum analyzers lack the following additional features: Amplitude calibration at any frequency, a low noise synthesized first local oscillator, and low noise second and third local oscillators with very accurate frequencies. The amplitude calibration should be such that the spectrum analyzer either calibrates itself without the use of an external signal after certain time periods (for instance, every minute), or at the beginning and at the end of a

measurement program. Furthermore, it should be possible to trace this amplitude calibration to an external power standard so the traceability mentioned in the beginning is maintained.

Last, but not least, the spectrum analyzer should be capable of measuring spectral density of broadband signals so electro-magnetic interference measurements can be made. Having these features, the spectrum analyzer is an ideal instrument for an automated microwave test station where the following measurements have to be made:

- A. Amplitude and frequency measurements of a series of generated or received signals.
- B. Gain, loss, input VSWR, and output VSWR, using either a tracking generator, or a synthesizer as a source.
- C. Leakage measurements, conversion measurements, harmonics measurements, intermodulation measurements, and interference measurements, all being measurements of signal amplitudes over a wide range of frequencies.
- D. Noise figure measurements.
- E. Evaluation of frequency stability, close-in noise, peak fm, and incidental am and fm measurements of generated signals.
- F. Frequency modulation and amplitude modulation characteristics measurements, including single side band measurements.

Obviously, a lot more measurement capabilities can be described, but this would go too far in this short report.

V. Signal Generators

Traditionally, the signal generator which is capable of simulating any microwave signal is a mainstay in any microwave measurement or test system. The trend has been to get away from the manually

tuned cavity type microwave signal generator, and go to the synthesized signal generator. We distinguish essentially between three synthesizing techniques:

- A. Locked frequency technique. This is the simplest technique where the frequency of a free-running oscillator is locked to a frequency standard using a counter, keeping the average frequency of the free-running oscillator at one predetermined frequency. The advantage of this scheme is that it is simple to implement and not too expensive (presently, it takes a sweeper and a lockable counter); the disadvantage is that the time to lock the frequency up might be several seconds and the close-in noise of the free-running oscillator is not improved. The scheme is identical to an operator continuously adjusting the frequency dial on a free-running generator to maintain a constant reading on a counter. A further disadvantage is the complicated remote frequency selection.
- B. The second scheme is the so-called indirect frequency synthesis scheme. The scheme consists of a voltage tunable oscillator being phase locked to a reference signal with the frequency division by the oscillator and the phase lock input adjustable. There are many versions of this type of synthesizer, since it is the preferred one. Its advantage is that it uses a minimum amount of turned-on oscillators minimizing the number of spurious output signals, and because the number of components is reasonable. This scheme also will clean up the close-in noise of the tunable oscillator within the bandwidth of the phase lock circuit. Obviously, this indirect

synthesizer can be remotely controlled which means that any frequency can be selected automatically.

- C. The third scheme of frequency synthesizers is called the direct synthesis which essentially consists of a cleverly arranged set of fixed frequencies, always available in the synthesizer which can be mixed, multiplied, etc. together to form the desired output frequencies. The disadvantage of this scheme is the large number of spurious signals created by all the fixed frequencies (requiring a lot of shielding, which makes the instrument heavy), and the large number of electronic parts. The big advantage of this synthesizer is its frequency switching speed. This synthesizer would allow to simulate systems with very rapidly changing frequencies (switching speeds below 1 microsecond) which are the mainstay of secure communications systems, ECM systems, and special radio systems.

- D. Synthesized microwave signal generators consist of a RF synthesizer and frequency multipliers, amplifiers, etc. to increase the frequency range of the actual synthesizer. Because of the difficult development of such a synthesizer which requires a long time, only a few microwave synthesizers are available with the optimal one still missing. The optimal synthesizer should cover a frequency range of 1 MHz to 26.5 GHz, has very low close-in noise, a switching speed of a millisecond, high power output to at least about +10 dBm, and all the modulation capabilities which are now-a-days used with

microwave signals: wideband fm, narrow band fm, phase modulation, F.S.K., amplitude modulation, very short pulse modulation, and combinations of these modulations. It should also be possible to switch the power level to any number between +10 dBm and -120 dBm.

As stated before, this instrument together with a spectrum analyzer would form a very versatile microwave test system with good accuracy.

VI. Instruments for measuring and generating interfering signals

Due to the extensive use of electronics in any system, the problem of interference and susceptibility to interfering signals is becoming very acute. The military had recognized this problem a long time ago, and is the only agency which controlled electro-magnetic interference and susceptibility by imposing specifications on most systems, components, etc. which they purchased.

With the advent of personal computers, CRT readouts, modems, etc. appearing in nearly every office, the measurement of electro-magnetic compatibility has become very important. Because of the many types of measurements (narrow band signals, broadband signals, magnetic fields, electrical fields, electromagnetic fields, RF currents, RF voltages), the instrumentation desired should be designed to make accurate measurements in the presence of all kinds of signals, be able to calibrate itself accurately, and provide readout programs so that the user can see immediately

whether the system under test meets its interference specifications.

Great progress has been made in the last few years to produce computer operated measurement systems preprogrammed to the latest interference and susceptibility specifications. Furthermore, antennas for measuring interfering signals or for generating fields for susceptibility measurements have been well defined. However, since these measurements always occur in the near field of these antennas, more work is necessary to define properly the near field antenna factors, and to improve the measurement environment to reduce standing waves which can cause large measurement errors.

VII. Desirable features in modern microwave instruments

As stated in the beginning, the microwave instrument industry has not only developed a lot of new instruments in the last few years, but has tried to reduce the level of competency to use these instruments and make accurate microwave measurements by providing self-calibration routines, measurement programs, annunciators to state when a condition is occurring which violates a measurement. As a matter of fact, talking as an instrument design engineer, it takes alot more time to develop the software for a modern microwave instrument than to develop the hardware, since the designer tries to anticipate every measurement which can be made with that particular instrument, and put it as a program into the microprocessor of the instrument. Sure, every modern instrument has IEEE-bus capability. This allows a measurement system designer to assemble the instruments for a given system, and in a controller store the commands for the instruments to make the measurements the way he

wants it. This way of preparing an automatic measurement is time consuming and expensive. It is obviously more satisfactory if the designer of a microwave instrument foresees all the measurements which can be made and, for instance, comes up with a clever calibration routine and a clever readout routine, so no additional computer is necessary to tell the instrument what to do.

Because of the continuously increasing frequency range which modern microwave instruments cover, maintenance and repair is becoming more and more difficult. Most microwave components are now MIC (microwave integrated circuits) type components which cannot be repaired, except in designated centers or by the manufacturer himself. Because of the complexity of these instruments, all modern microwave instruments should have the capability to test themselves. A test program should be provided for each board. The microwave industry is doing that, making maintenance and repair simpler and less time consuming.

However, most important is the integrity of a modern microwave instrument. It's got to keep on working, since it is so expensive that most agencies, companies, etc., can only afford the number of instruments they really need, and cannot set a few aside as spares. Again, the advent of MIC circuitry and more and more digital circuitry is improving the reliability of modern microwave instruments, and this will continue.

New Measurement Solutions for Low Frequency Systems

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Given the current emphasis on microwave and ultra-high frequency technology, can there still be any interest in low frequency measurements? Measurements in Hz or even kHz would seem to be passe, given the existence of instrumentation that operates comfortably in the GHz domain. Isn't faster always better?

Apparently not. Low frequency measurements remain vital even today, because so many physical phenomena - vibration (e.g. rockets), acoustics (e.g. submarines) and electrical signal analysis (e.g. power supply design) - occur in the low frequency area. A convenient way to observe what's happening is with spectrum analyzers. Here are a few examples of how DoD agencies apply spectrum analysis:

Spectrum Analyzer Application Areas

- Sonar Development
- Low Frequency Data Links
- Troop Movement Detection
- Production Testing of Torpedos
- Transfer Function of Servo Systems
- Flow Studies in Nuclear Reactor Cooling Design
- Harmonic Distortion

Presented at The American Defense Preparedness Association Meeting on "Electronic Test Equipment Industry Response to Emerging Defense Requirements", Arlington, VA, May 11, 1984

To see how spectrum analysis might apply to your area, let's back up a minute and consider some practical examples.

Vibration phenomena offer an excellent vehicle for discussion. Figure 1 shows an amplitude - time signature of a vibration transducer mounted on the bearing housing of a rotating machine. The curve shows how the housing vibrates with time. The housing vibration, in turn, is caused by the main shaft vibrating against the bearing assembly. From the figure we see that a complex, periodic vibration signal is being transmitted from the shaft to the housing to the transducer. It would be difficult from a curve such as this to determine how fast the shaft is spinning and what other vibration effects (resonance for example) are occurring.

What we're saying in other words, is that the information presented as it is in the time domain, is not optimum for our needs. Now, if we could display the same amplitude information as a function of frequency, we might stand a better chance of sorting things out.

Figure 2 shows the type of display we're looking for. Using a spectrum analyzer, we've transformed the time-domain information into a frequency domain representation. The large peak at the left occurs at 170 Hz, and corresponds to the running speed of the machine. We also observe overtones or harmonics of the main peak at 340, 510, 680, 850, 1020, and 1190 Hz - i.e. at 2-3-4-5-6-7 times running speed. This information is useful if we are attempting to diagnose the condition of the bearings and determine when, or if they should be serviced. Sometimes, it's useful to display both the time and frequency spectra together (Figure 3). We'll see another example of this when we discuss time panning. As it turns out, for the purposes of illustration we set this particular machine to a speed that was deliberately unstable, in order to present the complex time waveform shown in Figure 1.

VIBRATION OF A BEARING HOUSING ON A ROTATING MACHINE

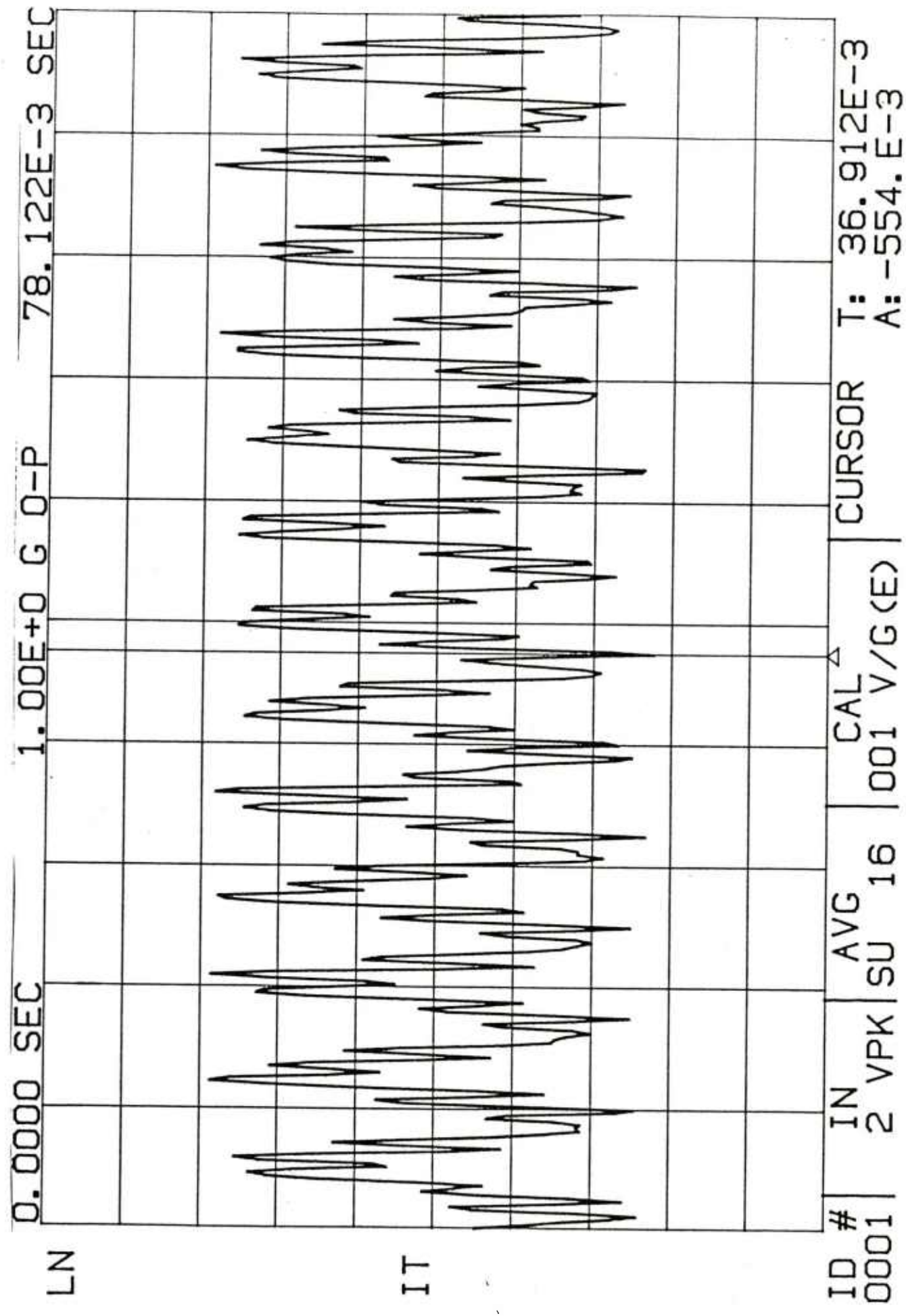


Figure 1

VIBRATION OF A BEARING HOUSING ON A ROTATING MACHINE

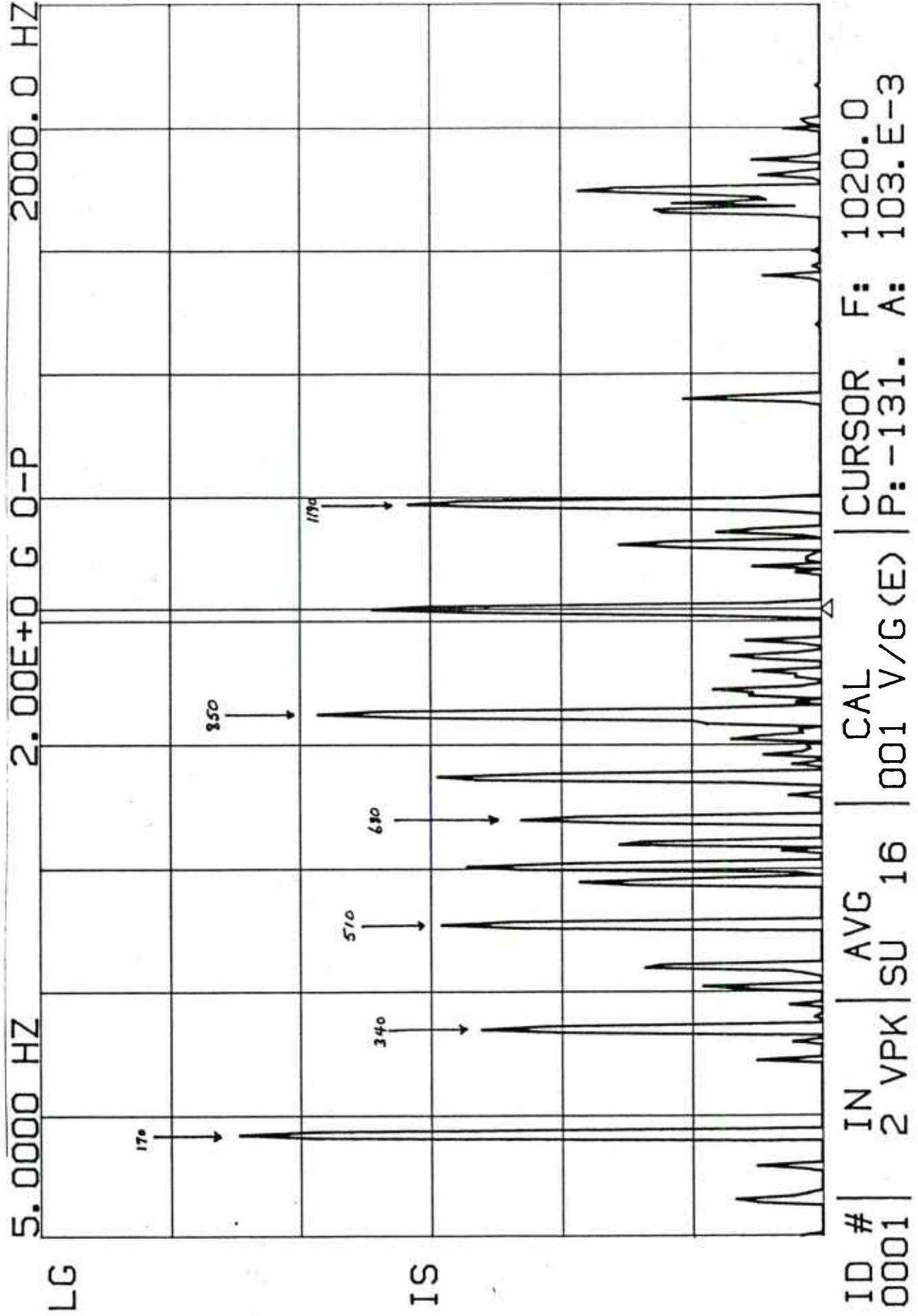
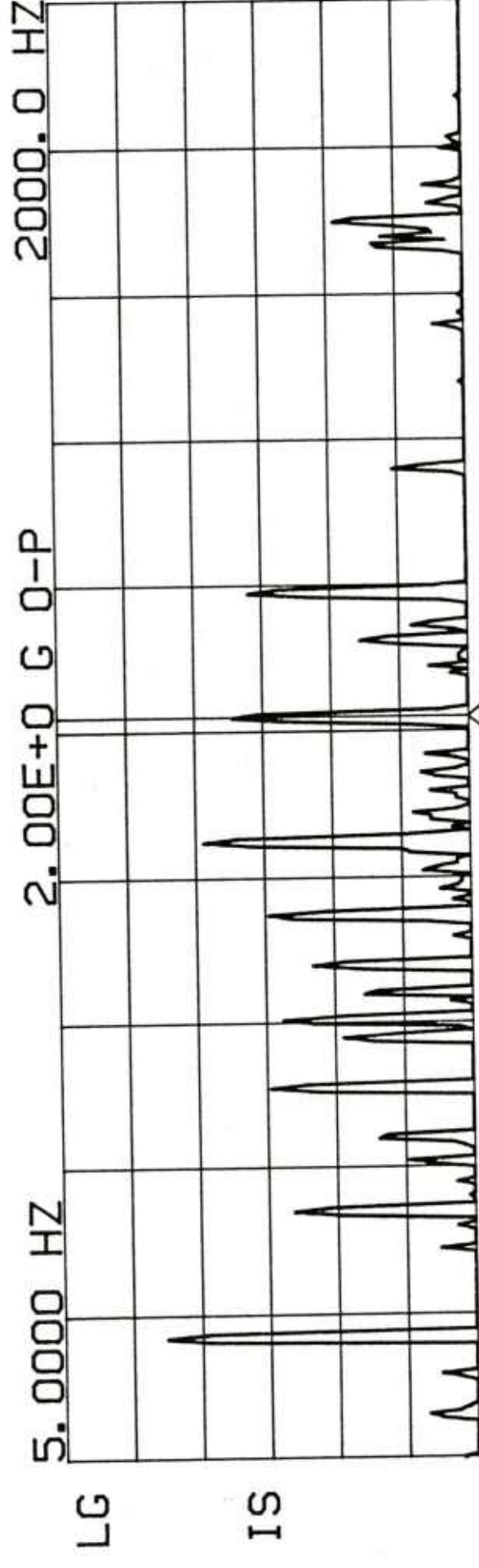
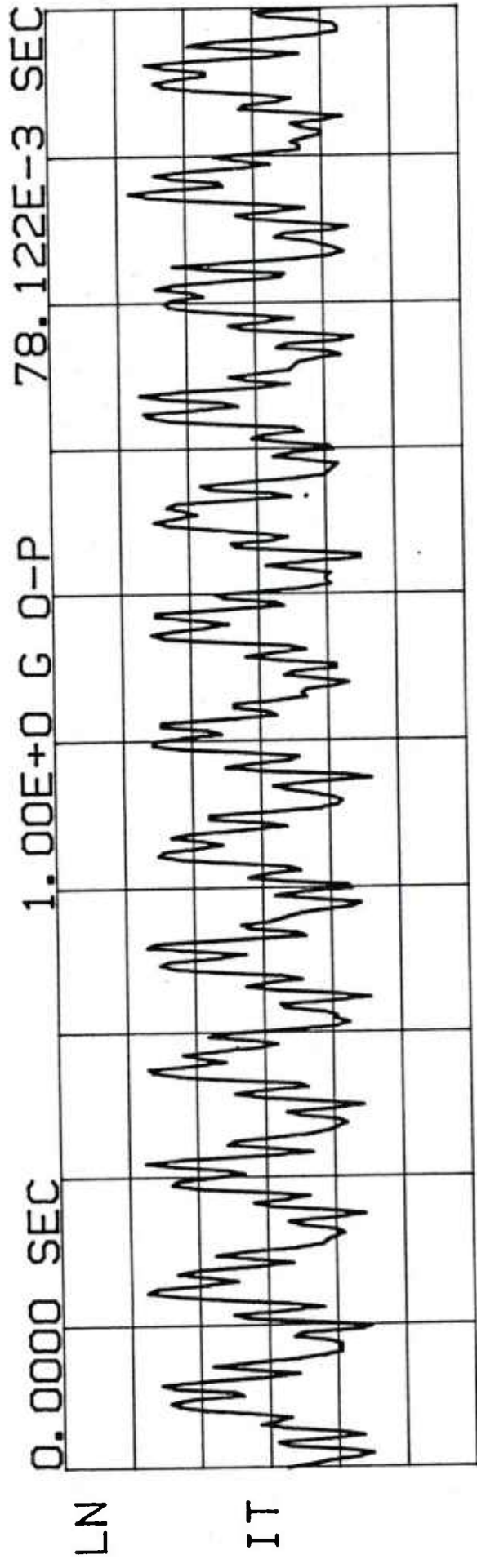


Figure 2

VIBRATION OF A BEARING HOUSING ON A ROTATING MACHINE



ID # | IN | AVG | CAL | CURSOR F: 1020.0
 0001 | 2 VPK | SU 16 | 001 V/G(E) | P: -131. A: 103.E-3

Figure 3

Figure 4 shows a somewhat simpler waveform. The four sinusoids that comprise the complex time waveform are sorted out by the spectrum analyzer using Fast Fourier Transform techniques, and the amplitude information at each frequency is displayed. It is important to understand that the instrument is simultaneously analyzing all frequencies (typically 400) within the bandwidth of interest.

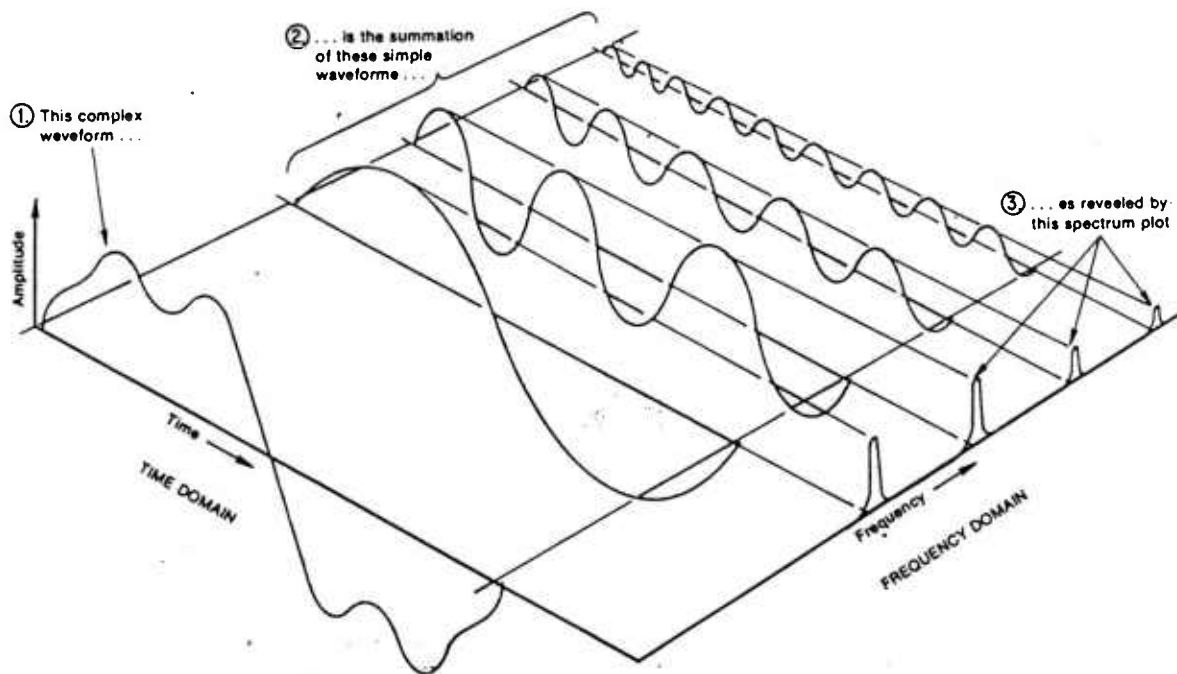
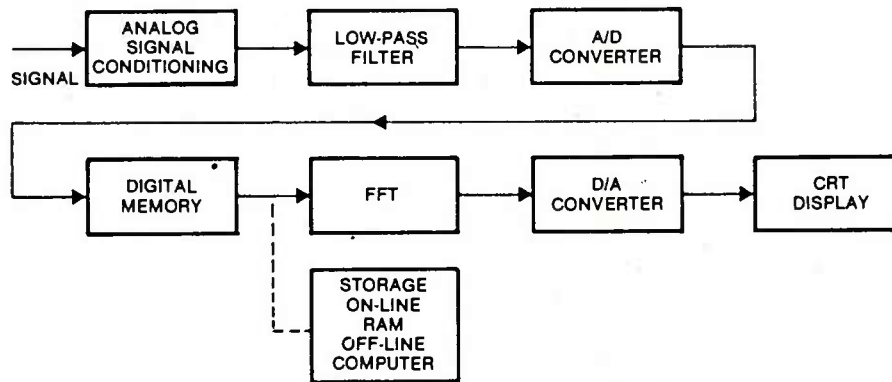


Figure 4. Time domain and frequency domain representation of a complex sinusoid.

Let's spend a moment to review how a spectrum analyzer works:



Block Diagram of Spectrum Analyzer

Figure 5.

A time-varying signal is presented to the input of the analyzer where it is either amplified or attenuated. The signal is then routed to a low-pass filter which prevents distortion of the original signal by alias signals introduced in the subsequent sampling process. The signal is then sampled and converted to the corresponding digital signal. Sampling intervals are determined by the resolution required for the measurement. Greater resolution leads to longer sampling times. The digital information is then stored in memory and converted to the frequency domain through the FFT algorithm. PROM-based intelligence allows optimum formatting (scaling, labelling, etc.) of the data prior to digital plotting of off-line storage. Reconversion of the digital information to analog form permits display on a CRT.

There are many commercially available spectrum analyzers. Selection of an analyzer for a particular application can be simplified by considering the following performance criteria.

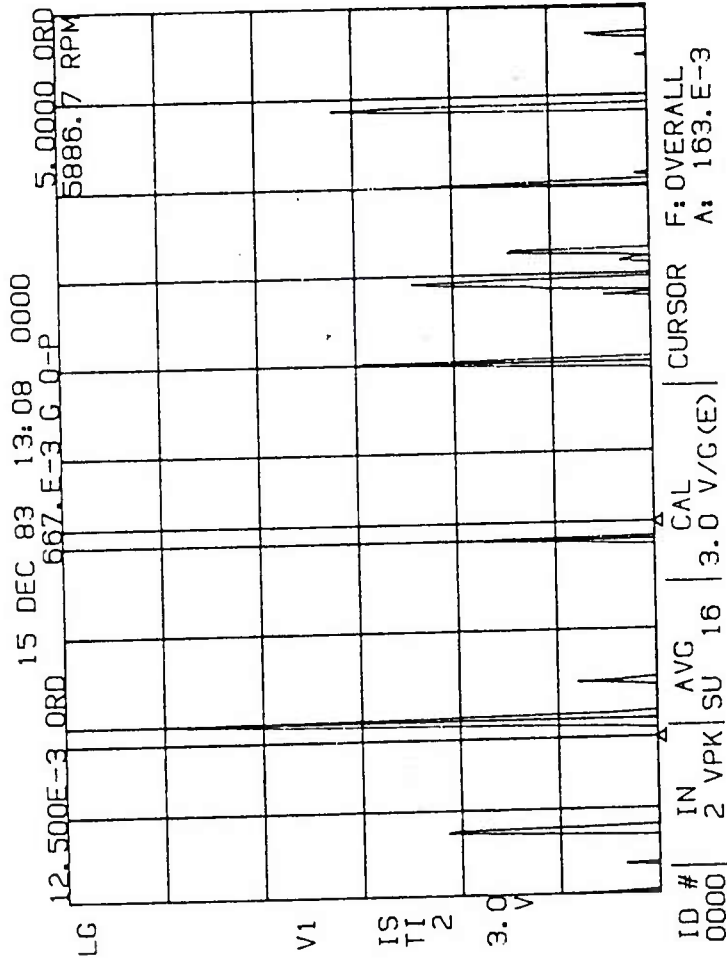
Spectrum Analyzer Selection Criteria

- Bandwidth
- Number of Channels
- Real Time Rate
- Resolution
- Transform Size
- Data/Panel Storage
- Formatting & Data Reduction
- Time/Frequency Averaging
- Windowing
- Data Buffer

With the availability of low-cost microprocessors and digital memory, spectrum analyzers now incorporate increasing amounts of data reduction: They are becoming true spectrum analyzers rather than merely spectrum measurers. Many data presentation forms are now available.

Plot Formats

- Screen Plot** - Amplitude vs time or RPM
- Report Plot** - Screen Plot + Setup Parameters
- Stack Plot** - Amplitude vs Frequency vs Time
Amplitude vs RPM vs Time
- Peak Picking** - Screen Plot with Peak Location and
Amplitude Table
- Cursor Plot** - Amplitude vs time or RPM
Phase vs time or RPM
- Polar Plot** - Amplitude and Phase



PEAK PICK ON TRACE 1

G O-P

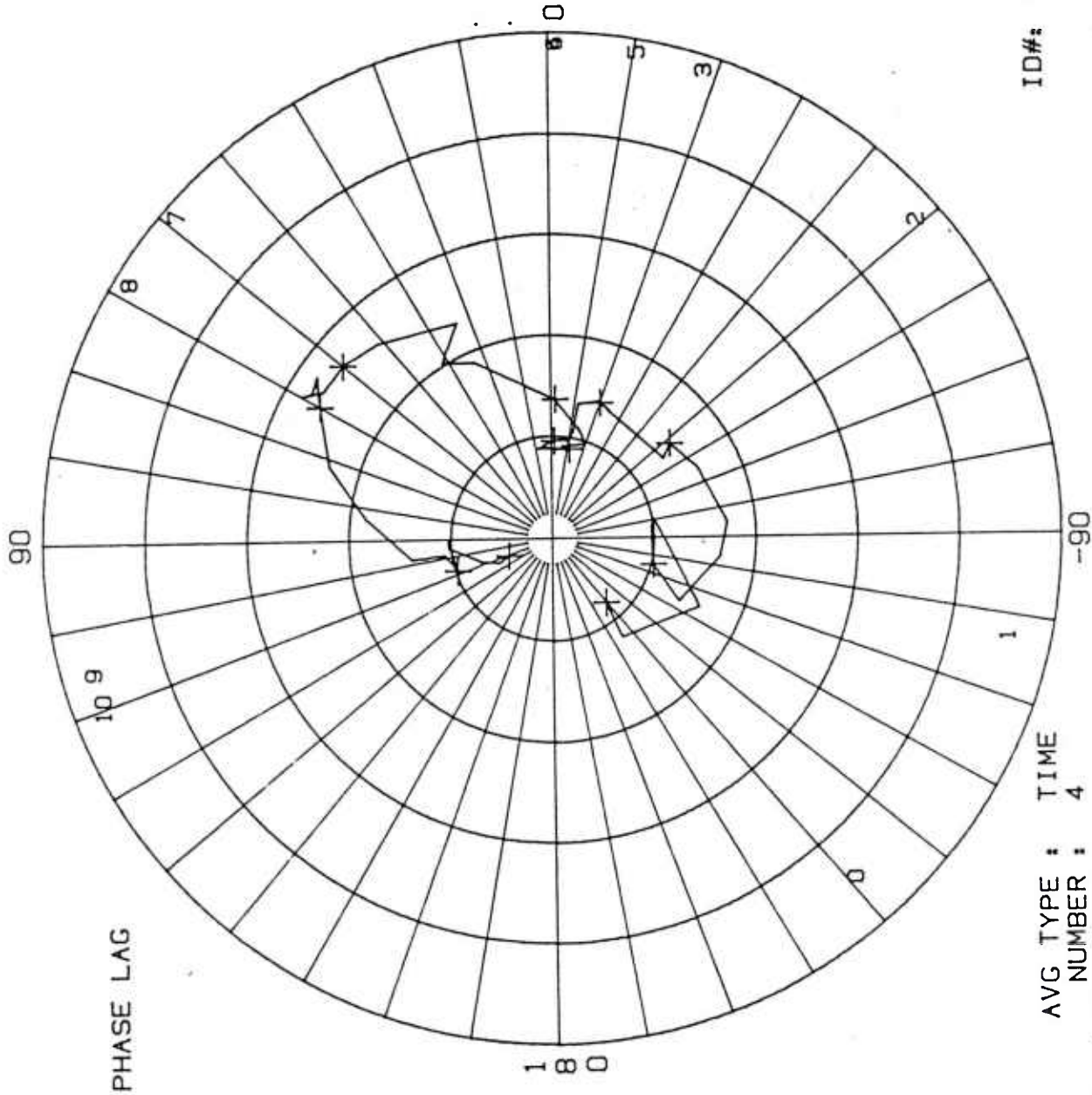
ORDERS

7.38E-3	.37499
161.E-3	1.0000
4.53E-3	2.0000
19.5E-3	3.0000
10.2E-3	3.4624
7.14E-3	4.0125
26.1E-3	4.4375

15-DEC-83

14:22:50

Figure 6 - Peak Pick Plot



MARKER	RPM	INCH P-P
0	2028.9	69.9E-6
1	2341.9	87.3E-6
2	2732.6	126.E-6
3	3080.0	120.E-6
4	3421.0	81.5E-6
5	3556.1	75.7E-6
6	3821.4	116.E-6
7	3928.4	227.E-6
8	3982.0	223.E-6
9	4300.0	83.4E-6
10	5342.5	38.8E-6
MAX	3936.1	241.E-6

ID#: 0000 17-FEB-84 11:39:56
TO 17-FEB-84 11:42:59

AVG TYPE : TIME
NUMBER : 4
CALIBRATION : 3.0 V/G
INTEGRATION : 2
WEIGHTING : ON

RADIAL : LN INCH P-P
MAX : 407.E-6
MIN : 0.00

10 ORDERS WAVETEK

Figure 7 - Polar Plot

PLOTTED
17-FEB-84
12:22:31

ID#: 0000

12:15

17-FEB-84

FIRST TRACE STORED

6667. E-3

97

667. E-6

G O-P

12:16

12:15

12:15

12:15

12:15

12:15

12:15

12:15

12:15

12:15

12:15

12.15

12.15

10.000 ORD/

25.000-03 ORD

INSTANT SPECTRUM
FROM MEMORY 5

CALIBRATION :

3.0 V/G

INTEGRATION : OFF

WEIGHTING : ON

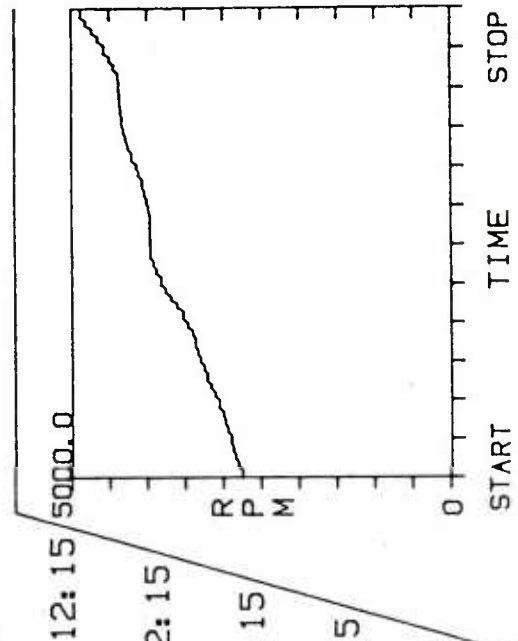


Figure 8 - Stack Plot

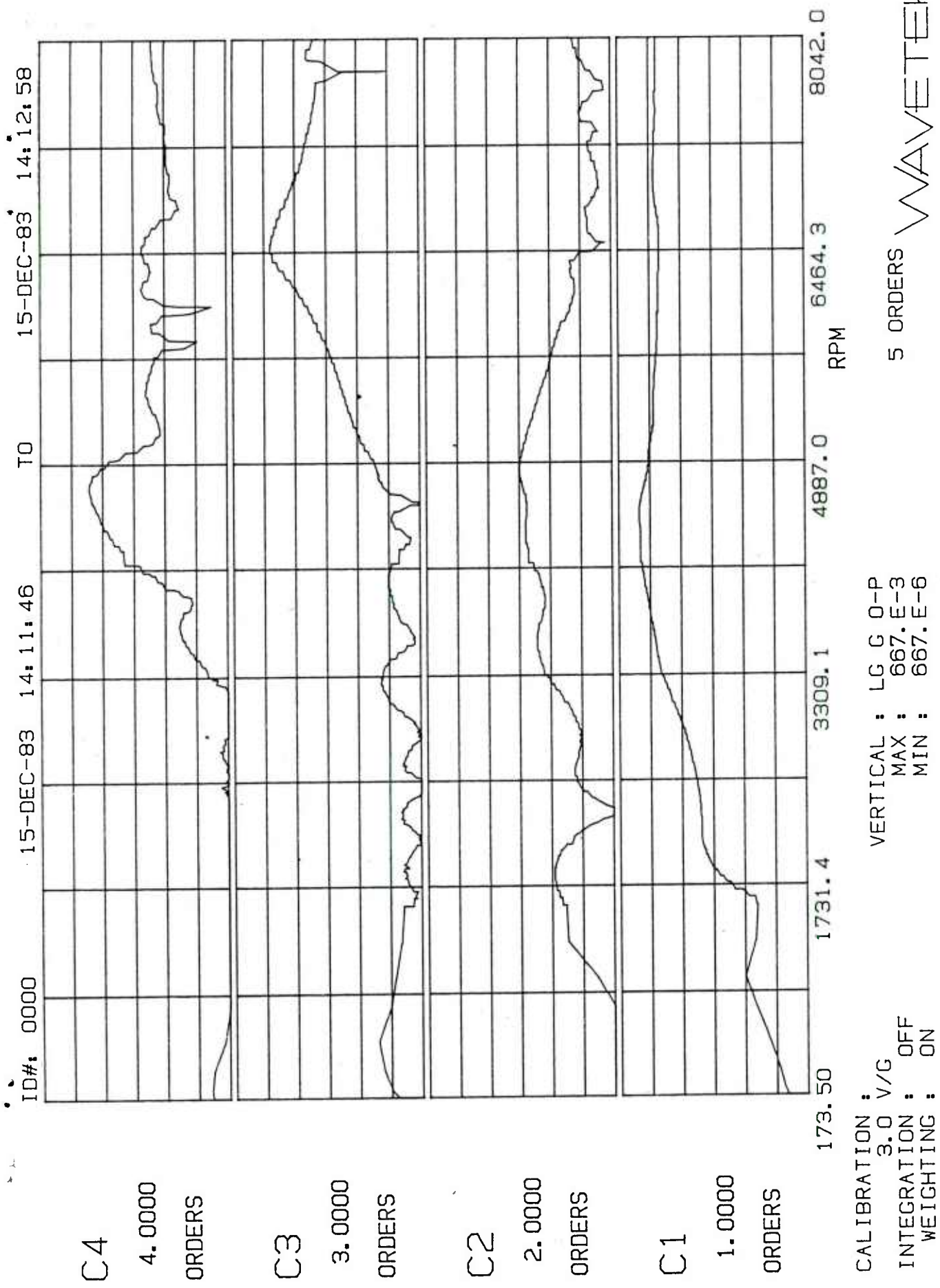


Figure 9 - Cursor Plot

Examples of a peak pick plot, a polar plot, a cursor plot and a stack plot (with a derived rpm time plot) are shown in Figures 6-9.

With all the emphasis on frequency domain measurements, it's important to understand that spectrum analyzers can also help in the time-domain. As an example consider the transient capture capability of a spectrum analyzer with the ability to perform "time - panning". Time panning can be thought of as examining a movie - frame-by-frame.

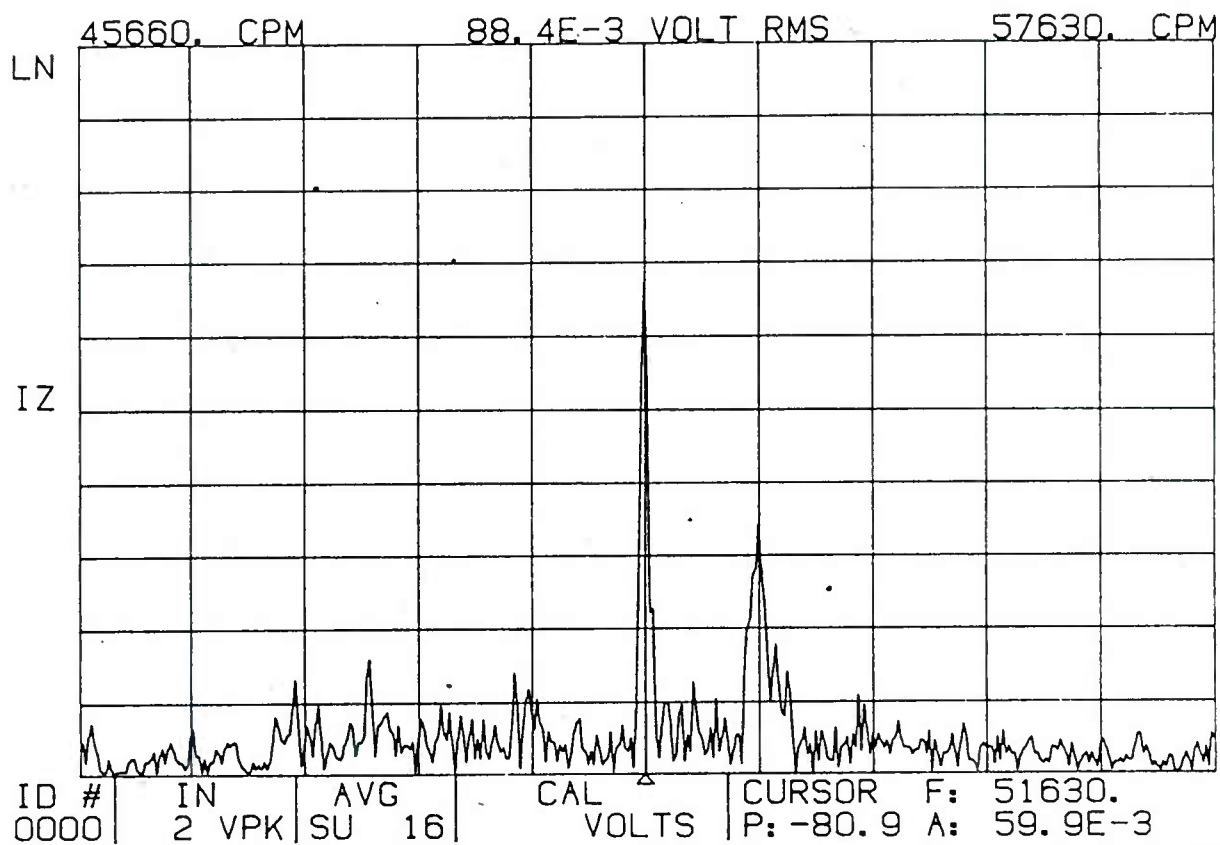
Time Planning Application

- 800 ms transient "squeal" from ship's engine room is captured in Analyzer's data buffer
- Panned time record to locate high frequency (870 Hz) component
- Isolated problem to a seal rub at propellor's cutlass bearing at critical speed of 585 RPM

In our example from a ship's engine room, we capture a burst of acoustic data in the analyzer's 10K time buffer (Figure 10 shows the frequency spectrum of a 1K slice), then "pan" through the buffer to watch an 870 Hz tone begin to appear, build in magnitude, then subside (Figures 11-14). The entire event only lasts 800 ms, so the ability to capture the transient, and examine the time record later is important.

Two-Channel Analyzers

Given that a single channel spectrum analyzer is a useful device, is a two-channel analyzer twice as useful? A two-channel analyzer opens up a whole new dimension in signal processing by giving us the ability to examine causality - cause and effect. With a two-channel instrument we can measure the response of a device to an applied stimulus. The stimulus can be a simple sine wave, a swept sine pattern, a mixture of sine waves, an impulse, band-limited noise, or broadband noise. Because it sorts out 400 frequencies at one time, the spectrum analyzer can



Zoom Processing
Looks at all 10,240 points in the time record
Cursor at 860 Hz.

Figure 10

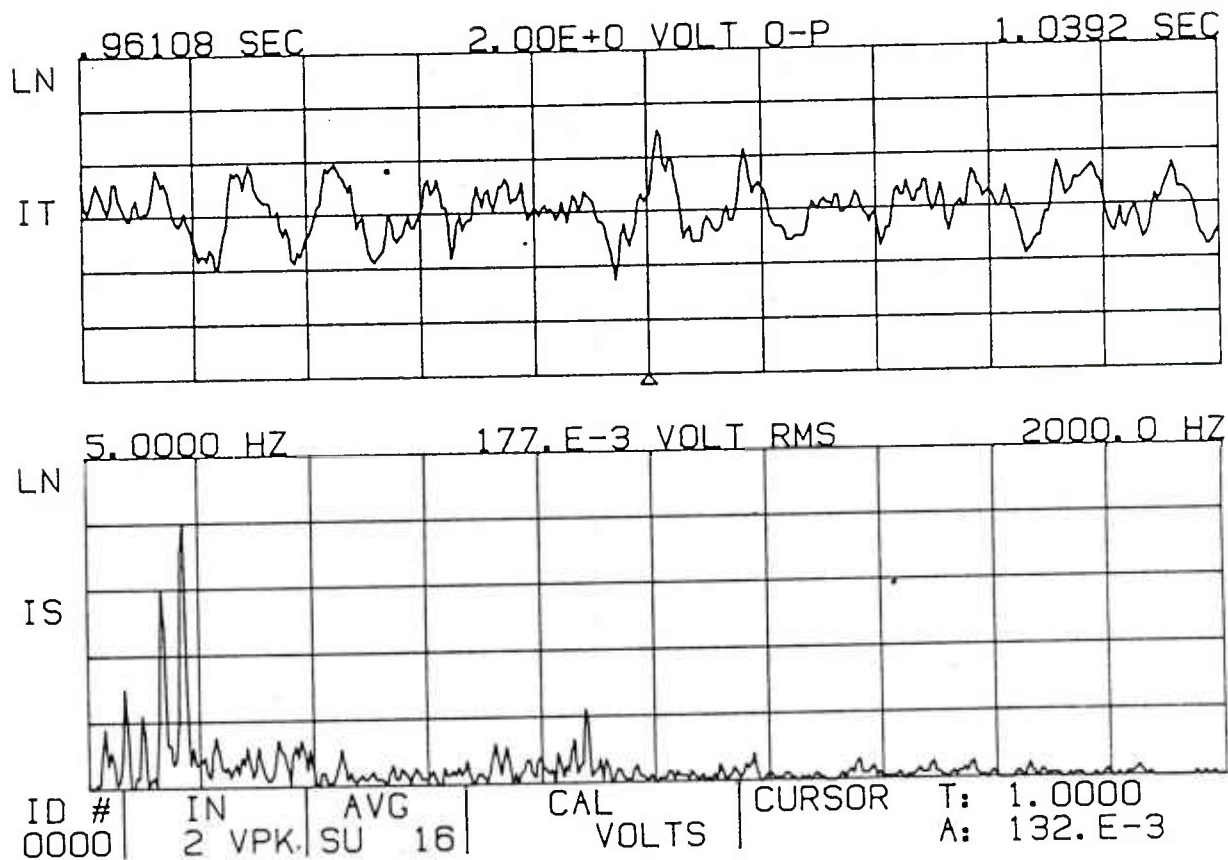
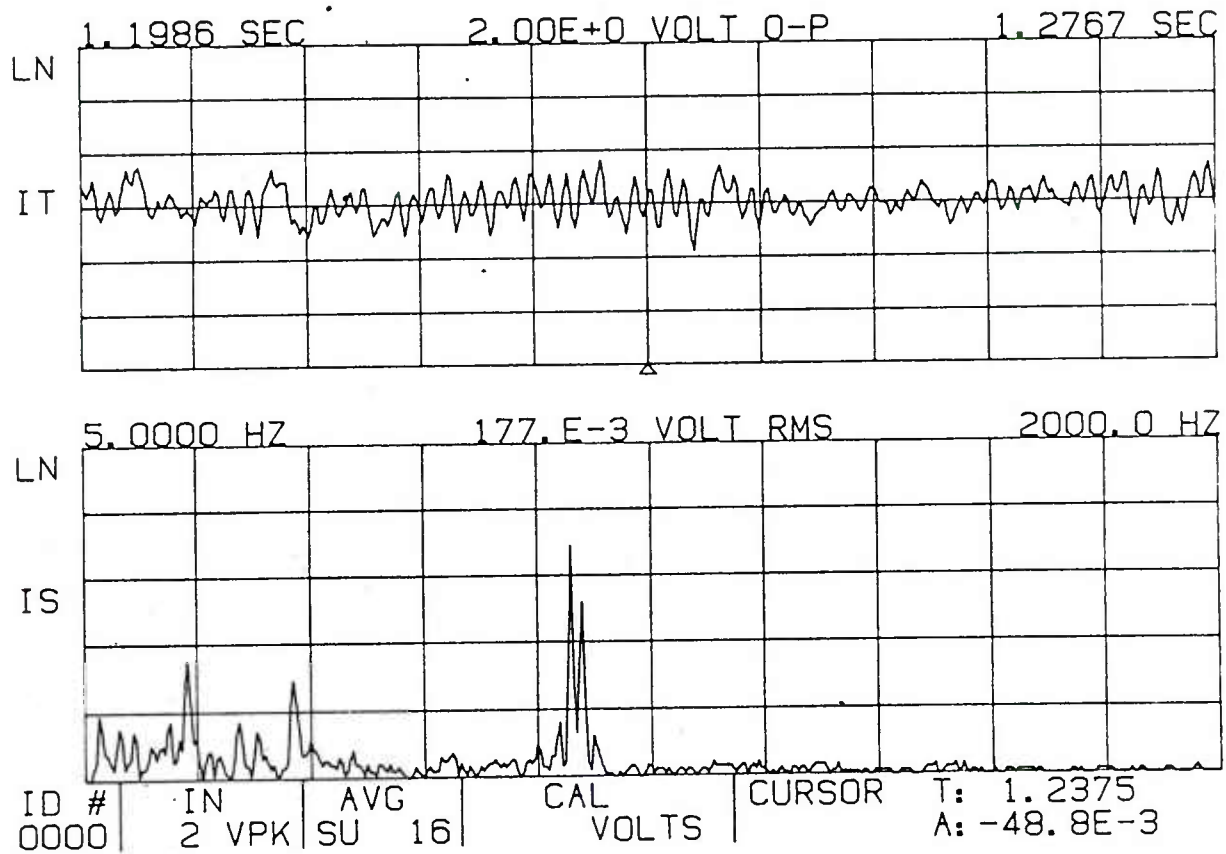
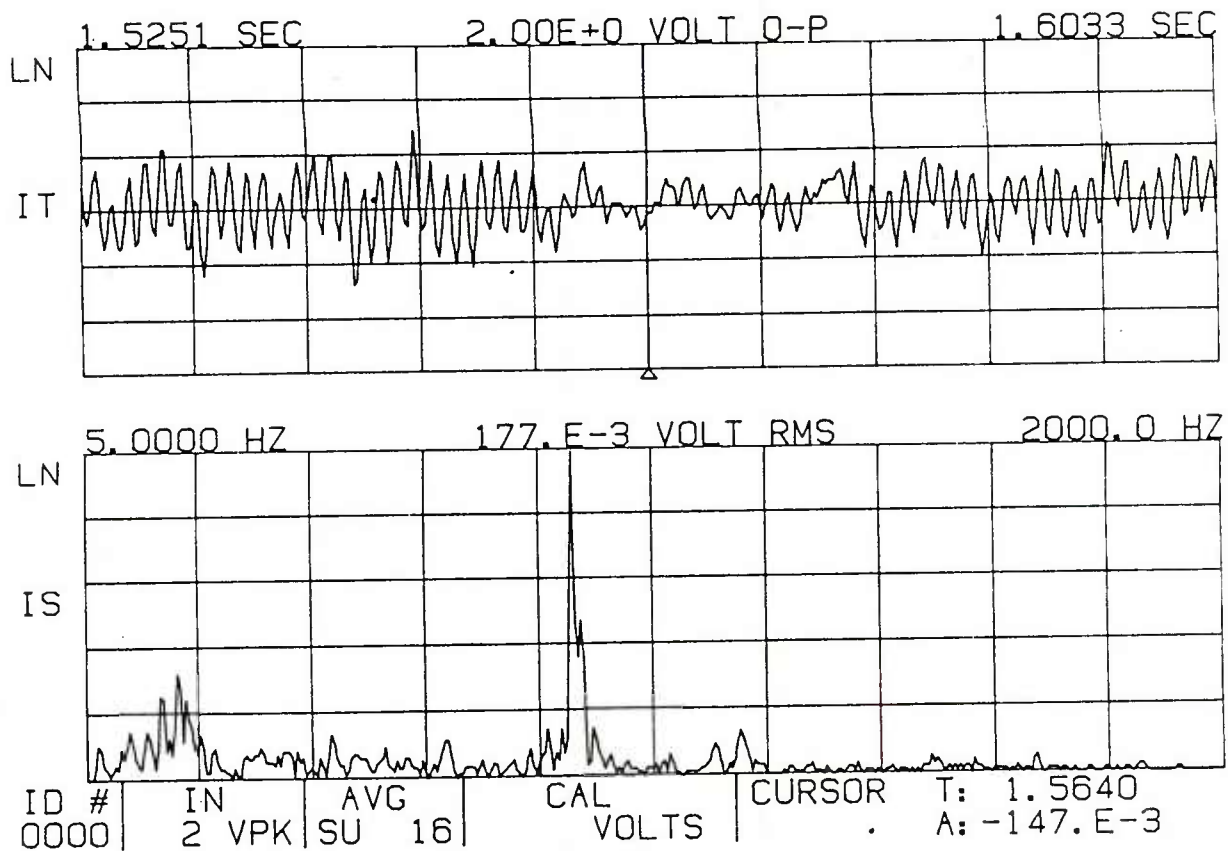


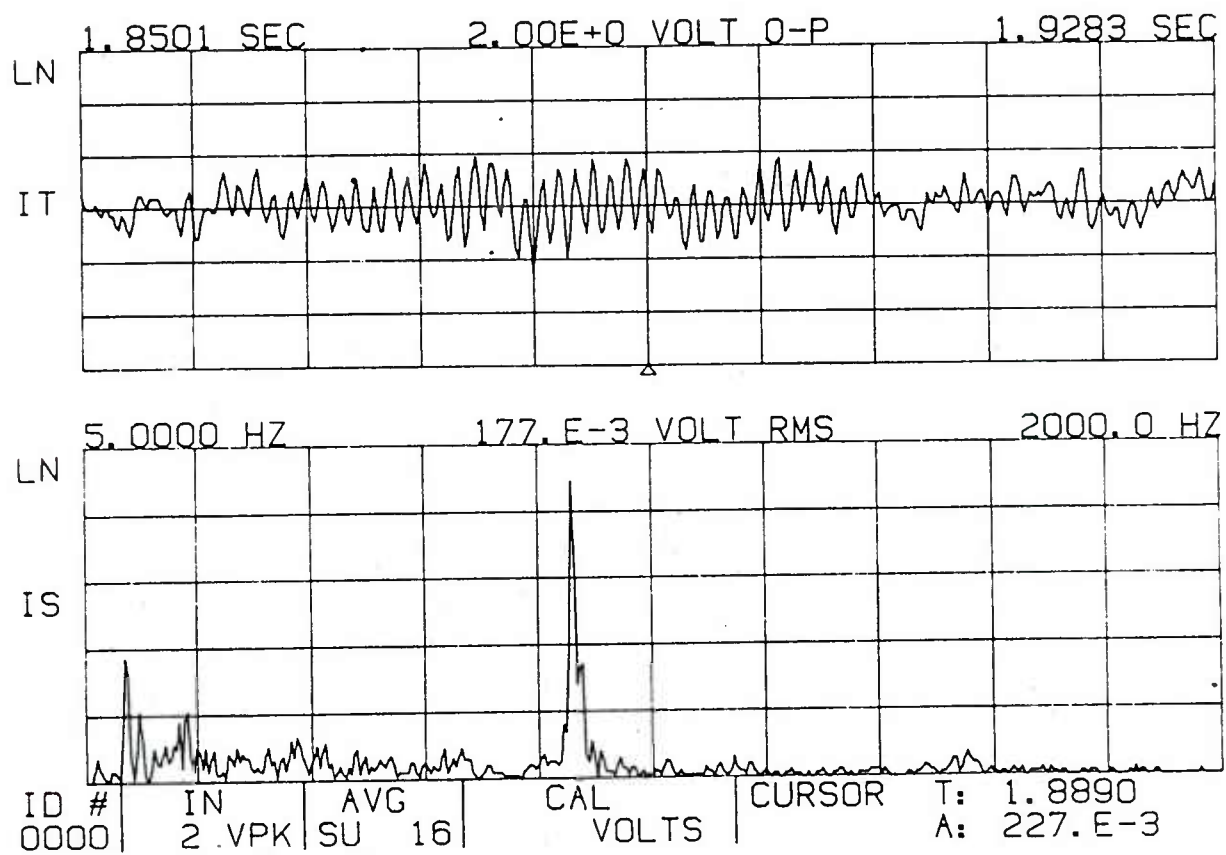
Figure 11



Time Panning - Second Slice (T = 1.20 → 1.28 sec)
870 Hz tone begins to build.



Time Panning — Third Slice (T = 1.53 → 1.60 Sec)
870 Hz tone continues to build.



Time Panning - Fourth Slice ($T = 1.85 \rightarrow 1.93$ sec)
870 Hz tone beginning to subside

measure the response to all of these different stimuli, and in some cases supply the stimulus as well. Two channel analyzers provide additional measurement capabilities and signal processing applications. One of the most important is coherence - a measure of how much of the system response is caused by the excitation. Coherence also provides a measure of the linearity of the system response.

Two Channel Spectrum Analyzer Measurements

Transfer Functions - Magnitude & Phase vs Frequency

- Bode Plots

Nyquist Plot - Imaginary vs Real (Polar)

Cross Spectra

Coherence & Coherent Output Power

Auto Correlation & Cross Correlation

Impulse Response

Transmissibility

The ability to measure transfer functions, means that two channel analyzers can play a significant role in evaluating electrical network and servo loop response - both open and close loop, as well as gain and phase characteristics.

Acoustics is another very important application of two-channel spectrum analysis. These instruments are used to determine acoustic noise levels, acoustic intensity, acoustic impedance of materials, and acoustic response to mention just a few areas.

Four-Channel Spectrum Analyzers

These instruments provide the ability to measure 4 different signals at one time. They are used in situations where parallel processing of 4 independent signals is required - e.g. modal analysis involving a stimulus signal and a tri-axial accelerometer, or an orbit plot for large turbine systems using four sensors. Four channel instruments often incorporate built-in computer capability with a full self-contained operating system that permits user-created custom software to be developed on the analyzer itself. Consequently, these devices can be used for automated data acquisition, signal processing, data reduction, data formatting, data storage, data transfer and control operations without the need for external computers.

As you can see, spectrum analyzers are powerful tools for solving many important defense-related problems, and as such are worthy of your consideration when low-frequency applications arise.

Following are a number of DoD application areas for spectrum analyzers.

Spectrum Analyzer Applications Areas

Aircraft & Missiles

- Space Vehicle/Airframe Vibration
- Aircraft Noise
- Wind Tunnel Tests
- Helicopter Gear Trains
- Jet Engines
- Landing Gear
- Flight Tests
- Towed Arrays for Sonar

AC Impedance

- Battery Testing
- Corrosion
- Coatings
- Electrochemical Kinetics

Intelligence

- Secure Communications
- Intrusion Detection
- Teleconference Equipment
- Design of Filters, Synthesizers, Amplifiers, Oscillators

Nuclear Energy

- Reactor Noise
- Mechanical Failure Prediction
- Control Rod Servos
- Pumps
- Noise & Vibration
- Loose Parts Monitoring

Spectrum Analyzer Application Areas

Radar

- Ionospheric Reflections
- Doppler Analysis
- Missile Miss Distance Testing

Rotating Machinery

- Pumps
- Engines
- Motors
- Blowers
- Fans
- Gears
- Belts

Structural Analysis

- Modal Analysis
- Finite Element Analysis
- Structural Modification
- Forced Response Analysis
- Operating Deflection

Underwater

- Ship Silencing
- ASW
- Torpedo Tests
- Hydrophone Tests
- Wave Motion
- Oceanography
- Sonar
- Ship Locating

AN OVERVIEW OF MEASUREMENT
SOLUTIONS FOR DIGITAL SYSTEMS

DICK LEMKE
LOGIC ANALYZER DIVISION MANAGER
TEKTRONIX, INC.
MAY, 1984

This overview of digital measurement solutions is divided into three sections. The first section consists of a summary of the digital instrumentation that is currently available on the commercial market today. The second section is a look at the technology trends that are driving commercial instrumentation suppliers to provide newer and more advanced features and better measurement solutions for the future. Finally, I would like to discuss the implications of exciting developments in design automation for electrical engineers and for manufacturing and service applications, and the implications for digital measurement instrumentation.

In the first section we see digital measurement instrumentation divided into two classes; the first class is instruments that provide both stimulus and response type of instrumentation in an ATE subsystem environment. The second class of digital instrumentation consists of products that stand alone and are portable. These are meant more for field service and manufacturing test applications.

The stimulus response type of ATE sub-system components that are available on the commercial market place cover a very wide range of performance. The range of performance for this kind of instruments is summarized in Table 1. In fact, no one commercial instrument supplies performance that hits all the maximums shown in the table. For any one particular application it's necessary to look at each instrument's characteristics very carefully. As the table indicates speed ranges to 660 MHz, channel capacity to 512 channels, and memory depths up to 4096 words.

One example of a stimulus response instrument is the Hewlett Packard 8180A and 8182A Series. The 8180 and 8181 provide the data generator portion of this combination, while the 8182 is the data analyzer. Speeds range from 1 hertz to 50 megahertz with channel capacity up to 128 channels at a memory depth of one thousand bits per channel. These units provide a very fine one hundred picosecond edge resolution with accuracies in the one to two nanosecond region.

Another example of stimulus response type of ATE sub-system instrumentation is the Interface Technology RS4000. This instrument runs from DC to 20 megahertz, typically up to a maximum of 512 channels and a maximum of 2048 bits per channel. There is an optional 100 megahertz timing generator that provides ten nanoseconds edge resolution.

Last but not least in this category is the Tektronix DAS 9100. DAS stands for Digital Analysis System. This product consists of a configurable and expandable mainframe into which can be plugged any one of a number of modules that provide a wide range of acquisition and stimulus performance. The DAS 9100 performance is summarized in Table 2. Acquisition speeds range from 10 megahertz all the way up to

660 megahertz with pattern generation across 80 channels at 25 megahertz. The DAS includes a color display and its own internal mass storage on a magnetic tape cartridge. Another feature of the DAS is the ability to connect it up with the Tektronix 8540 microprocessor integration unit. This allows a system under test with a microprocessor to be monitored by the 8540 micro-processor emulator while the DAS stimulates and acquires data from other portions of the unit. After data has been acquired by both the microprocessor emulation unit and the DAS 9100 it is time correlated between the two units using a time stamp probe and data correlation software running on a 8560 host CPU. The DAS may also be hosted to other types of computers through a RS232 port or the GPIB.

The second category of digital instrumentation that is commercially available today falls into a class that is portable. This class is not necessarily intended to be used as an ATE sub-system component. One example of this category of portable instrumentation is the Gould Biomation K105 Logic Analyzer which provides a combination of speeds and channels widths and includes microprocessor support. Another example of this category of instrumentation is the Hewlett Packard 1630 Logic Analyzer. It is available in three models which again provide a variety of data acquisition and microprocessor support features.

Again, last but not least is the Tektronix 1240 Logic Analyzer. The 1240 consists of a portable yet configurable and modular mainframe containing four card slots. These four card slots may be filled by selecting from a combination of two acquisition modules; one module provides 100 megahertz sampling speeds across 9 channels for hardware and timing analysis. The second module provides 50 MHz speeds across 18 channels and includes multiphase clocking and buss demultiplexing for microprocessor state analysis.

The 1240 has communication modules which plug into the back of the instrument to provide remote control line printer output and master /slave operation. Master/slave operation comes in two forms; one form consists one 1240 driving the slave 1240 over a telephone line; the second master/slave operation utilizes a host computer talking to a 1240 over a telephone line. In either case the remote 1240 can be hooked up to a system under test. When it finds a glitch it will ring up the master 1240 or the host computer and send the acquired data that goes along with the glitch and ask for further instructions.

For field service applications the 1240 has a series of battery backed RAM packs and ROM packs available. In either case a whole sequence of test set ups can be stored in these RAM packs or ROM packs. These test set ups may be tailored

for specific field service applications and can include instructions to the service technician who will be doing the work. For these applications a service technician need only read a label on a RAM or ROM pack and match that with the serial number or the model number on the unit under test. Then plug that ROM pack into the logic analyzer which can lead the technician through a series of test sequences.

Finally in this category of portable instrumentation there is the Sony Tektronix 300 Series Data Analyzers and Logic Analyzers. The 308 Data Analyzer acquires 8 channels of data at 20 MHz and includes a serial analyzer and a signature analyzer. Today you'll find the 308 aboard Navy ships as a test instrument for the AN/SLQ32 program and you'll find it servicing the Lamps-III equipment which is a helicopter based system.

The 318 Logic Analyzer provides 16 parallel channels at 50 MHz and includes a serial data analyzer. The 338 Logic Analyzer monitors 32 channels at up to 20 MHz and also includes a serial channel.

All three of these products are ultra light, ultra portable, and contain all of their accessories in a pouch on top of the instrument. They are very easy to learn how to use and to set up. The 318 and the 338 also include a remote programmable interface so that they can be controlled from a host computer.

Now I would like to provide a technological perspective that examines some of the forces that are driving digital instrumentation vendors to provide new solutions for the future. Logic Analyzers themselves are barely eleven years old. Tektronix second logic analyzer product was the 7D01 which was an oscilloscope plug-in. The 7D01 monitored 16 channels at up to 50 MHz and was a state-of-the-art instrument for its day. Just five years later Tektronix introduced the DAS 9100 which took a giant step forward in the kind of performance that a logic analyzer could provide. You recall the maximum speed of this machine is 660 MHz. The maximum number of channels that can be monitored is 104 and it includes pattern generation creating a self-contained stimulus response type of instrument. The change represented by those five years that separate the 7D01 and the DAS 9100 did not happen by accident. The need for speed was pushed by the increased speed of semiconductor components and by such programs as the military VHSIC developments.

Another force pushing for increased digital performance is the increasing complexity of microprocessors. The Intel 80186 and Motorola 68000 family for example are a far cry from their 8080 and 6800 predecessors. These changes in microprocessors have pushed logic analyzer vendors to provide

more channels, more speed, improved levels of triggering, multiphase clocking, buss demultiplexing, as well as assembly language disassembly support.

In order to keep up with this technology push digital instrumentation vendors have utilized the same high technology integrated circuit building blocks in their instruments, the same components the instruments are intended to test. The new Sony Tektronix 318 and 338 Logic Analyzers, for example contain three custom gate arrays used to reduce circuit board areas by more than half to fit the needed performance into the very small package that they represent.

In conclusion, digital instrumentation vendors have no choice but to keep up with these technology forces or they will not be successful companies and will go out of business. The pace of change is not slowing down. If anything, it is increasing. As an example, our 1240 Logic Analyzer has only been on the market for a year. We presently find one of our memory chip vendors wanting to cease production of a critical part. We have no choice but to engage in a re-design or stop production. In the future we will need to take increased advantage of our own internal integrated circuit processes to provide the performance needed in our instruments. We will rely on commercial vendor chips only where we are assured that demand for them will be high enough to force the chip vendor to provide production quantities over a long period of time. We cannot afford to continue to re-design our product again and again. The military services need particularly long term support for their systems. This means sustained production of digital instrumentation over a long period of time. We will have no choice but to use our in-house processes so that we can maintain control over the components and basic building blocks in our products.

Finally I would like to discuss the implications that the latest developments in Design Automation have for digital measurement solutions.

A picture of a whole product life cycle, with emphasis on the design portion is shown in Fig. 1. A new product evolves from a concept definition to a system design stage where the product is segmented into software and hardware design tasks. Today, tools are available that allow entry of a schematic at a computer work station followed by simulation of that circuit before committing the design to hardware. One of the outputs of the simulator can be a whole series of test vectors that are used to check the prototype. These test vectors can also be migrated into production test and field service applications.

An attractive concept currently being discussed is called coupled computer aided design and coupled computer aided

test. Here the design and the test process is all tied together with a common data base and data base manager. This data base communicates the test vectors created with the help of a simulator to digital measurement instruments used to test the engineering prototype and then to test the same device in production and in field service. The crucial ingredient is coupling the test hardware into the front end of the design process.

Tektronix has taken a first step in this direction with a new product called 91DVV. DVV stands for Das VLSI verification. This product consists of software that runs on a host computer and links the Das stimulus response instrument up to the output of a digital design simulator. The test vectors output from the simulator are converted to Das format and downloaded. The Das stimulates the device and data is acquired from it and uploaded to the host computer. Comparison is made to the output of the simulator to see if the device is doing what is expected. This product is a first step toward making coupled computer aided design and computer aided test a reality.

Another implication of computer aided design is that the design itself is now contained on a computer data base. The design is stored on magnetic media such as Winchester disks or magnetic tape. Thus in the future, configuration control and the logistics that are involved will be centered around this computer controlled data base. Today the primary vehicle for configuration control is paper. Blue prints describe systems today. I am sure we will enter a phase where we use both methods, both paper and magnetic media storage, but eventually we will have to put the control mechanisms in place and gain the confidence in a computer data base in order to take full advantage of the automation and flexibility that can be provided.

In conclusion, we have today a wide variety of commercially available digital measurement solutions for most any application that can be thought of. At the same time we see the vendors of digital instrumentation incorporating the latest technology as building blocks for future products. Future instruments will use the same technology that is driving us to develop new instrumentation. Future products will keep up with the increasing pace of change that is evident in this field. We have the latest developments in design automation at our disposal. The exciting thing is coupling these design tools to the digital measurement solutions such that test patterns developed in the design stage are easily transported and migrated into the production test and field service applications. This coupling has been slow in coming, but the first steps are now being taken.

TABLE 1

STIMULUS RESPONSE
SUBSYSTEM PERFORMANCE RANGE

<u>MODULE</u> <u>TYPE</u>	<u>MAXIMUM</u> <u>CHANNELS</u>	<u>MEMORY</u> <u>DEPTH</u>	<u>SPEED</u>	<u>EDGE</u> <u>RESOLUTION</u>
STIMULUS	512	2048	50 MHZ	0.1 NSEC.
RESPONSE	512	4096	660 MHZ	0.1 NSEC.

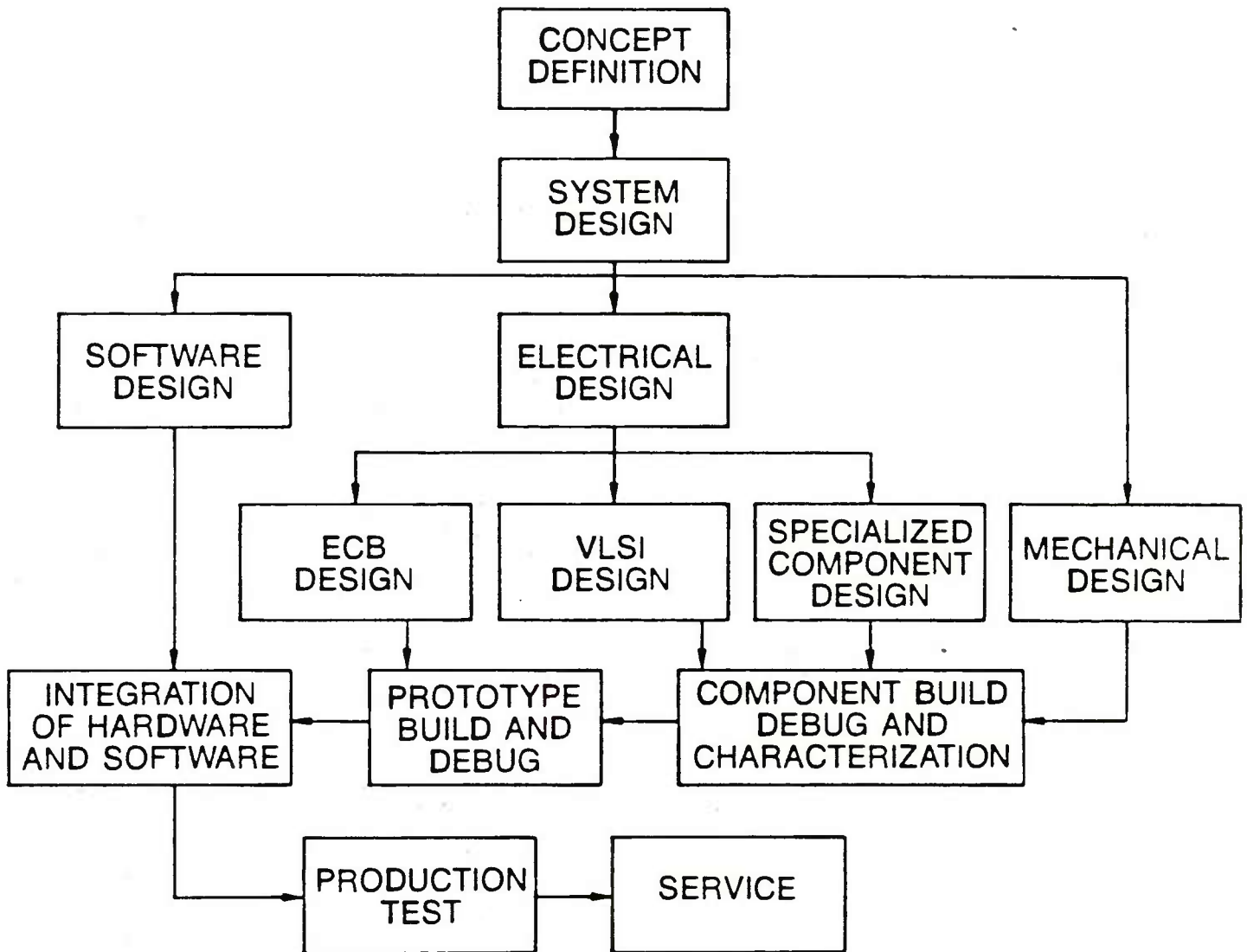
TABLE 2

DAS PERFORMANCE SUMMARY

<u>MODULE NAME</u>	<u>TYPE</u>	<u>CHANNELS PER MODULE</u>	<u>MAXIMUM CHANNELS</u>	<u>MEMORY DEPTH</u>	<u>SPEED</u>
91A04A/ 91AE04A	ACQUISITION	2/4	16	4096/ 2048	660 MHz/ 330 MHz
91A08	ACQUISITION	8	32	512	100 MHz
91A32	ACQUISITION	32	96	512	25 MHz
91A24/ 91AE24	ACQUISITION	24	96	1023	10 MHz
91P16/ 91P32	PATTERN GENERATOR	16/32	80	254	25 MHz

FIG. 1

PRODUCT LIFE CYCLE, FOCUS ON DESIGN



WILTON D. ALLEN
CRYSLER MILITARY PUB ELEC SYS
MGR NEW PROD DEVEL
5021 BRADFORD BLVD
HUNTSVILLE AL 35805

DICK ANDERSON
HEWLETT PACKARD
GEN MGR MICROWAVE COMM
4 CHOKE CHERRY ROAD
ROCKVILLE MD 20850

LAWRENCE A. ASCH
US ARMY CECOM
TMDE RPOC BR
DRSEL-PC-C-TM
FT MONMOUTH NJ 07703

LTG DONALD M. BABERS
US ARMY DARCOM
DEP CMDG GEN FOR MATERIEL READ
ATTN: DRCDMR 5001 EISENHOWER
ALEXANDRIA VA 22333

BARRY A. BELL
NAT. BUR. STDS.
GROUD LEADER
MET BLDG RM B162
WASHINGTON DC 20234

FRANK BORGHETTI
EATON CORP
ELEC INSTRU DIV
2070 FIFTH AVE
RONKONKOMA NY 11779

DUANE BOWANS
TEKTRONIX INC
GOVT. MARKETING/CONTRACTS MGR.
PO BOX 500, 54-064
BEAVERTON OR 97077

M. T. BRAID, JR.
WESTINGHOUSE ELECTRIC CORP
DEPT MGR L. S. D.
1111 SCHILLING RD
HUNT VALLEY MD 21030

STANLEY J. BROCK
HEWLETT PACKARD CO.
MILITARY ACCT PROG MGR
3000 HANOVER ST, BOX 10301
PALO ALTO CA 94304

RAYMOND V. BROWN
CANADIAN EMBASSY
2450 MASSACHUSETTS AVE., NW
WASHINGTON DC 20008

WESLEY BURNS
ALM INC
LOGISTICS ENG
1745 JEFF. DAV. HWY. STE 900
ARLINGTON VA 22202

DEL CALDWELL
NAVAL METROLOGY ENG. CNTR.
NAVAL WEAPONS STA, CODE 501
SEAL BEACH, POMONA ANNEX
POMONA CA 91769

DON CLINGEMPEEL
MANTECH INT'L CORP
2320 MILL RD
ALEXANDRIA VA 22314

EDWARD A. CONNOR
APPLIED TECHNOLOGY ASSOC.
SR ENGINEER
5103 A BACKLICK RD
ANNADALE VA 22003

LINDA COUTURE
BENDIX CORP
MKTG REP/WASHINGTON REP
1000 WILSON BLVD
ARLINGTON VA 22209

THOMAS F. DEVLIN
WESTINGHOUSE ELECTRIC
F-111 AIS PROG MGR
1111 SCHILLING RD
HUNT VALLEY MD 21030

JACK DOWNING
ADVANCED TECHNOLOGY, INC.
SR. ANALYST
2711 S. JEFFERSON DAVIS HWY
ARLINGTON VA 22202

MARVIN ELMOWITZ
DARSMC-QAI-I(D)
ARDC BLDG 62
DOVER NJ 07801

KEN ENGLAND
TEKTRONIX, INC.
GOV'T ACCTS-ARMY ACCT. MANG
3322 S MEMORIAL PARKWAY S203
HUNTSVILLE AL 35801

EUGENE FALLON
GENRAD INC
MGR, GOVERNMENT AFFAIRS
170 TRACER LANE
WALTHAM MA 02254

T. BING GARDNER
NESEA
P O BOX 98
ST INGOES MD 20684

JOHN E. GIFFORD
AMERICAN MGMT SYSTEMS
MGR BOSTON OPERATIONS
2000 WEST PARK DR.
WESTBOROUGH MA 01581 189

MARY ANN GILLECE
DEP UNDR SEC DEF (ACQ MGMT)
ROOM 3E144
THE PENTAGON
WASHINGTON DC 20301

JOHN GOON
DA, HQ ERADCOM
PRODUCT ASSURANCE & TEST
ATTN: DRDEL-PA 2800 POWDER MIL
ADELPHI MD 20783

GEFF GOVERMAN
EMERSON ELECTRIC
BUSINESS DEVEL DIR
8100 W FLORISSANT AVE
ST LOUIS MO 63136

DONALD C J GRAY
GENERAL SERVICES ADMIN
SPECIAL ASSISTANT TO ADMIN.
18TH & F STREETS
WASHINGTON DC 20405

PAUL GUERCIO
HEWLETT-PACKARD
4 CHOKE CHERRY ROAD
ROCKVILLE MD 20850

JAY HALPRIN
HEWLETT PACKARD
SALES REP
2750 MONROE BLVD
VALLEY FORGE PA 19482

LT. SCOTT HALWES
AIR FORCE LOGISTICS COMMAND
SA-ALC MMTA
KELLY AFB TX 78241

CHARLES J HARMON
GRUMMAN AEROSPACE
SOUTH OYSTER BAY ROAD
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